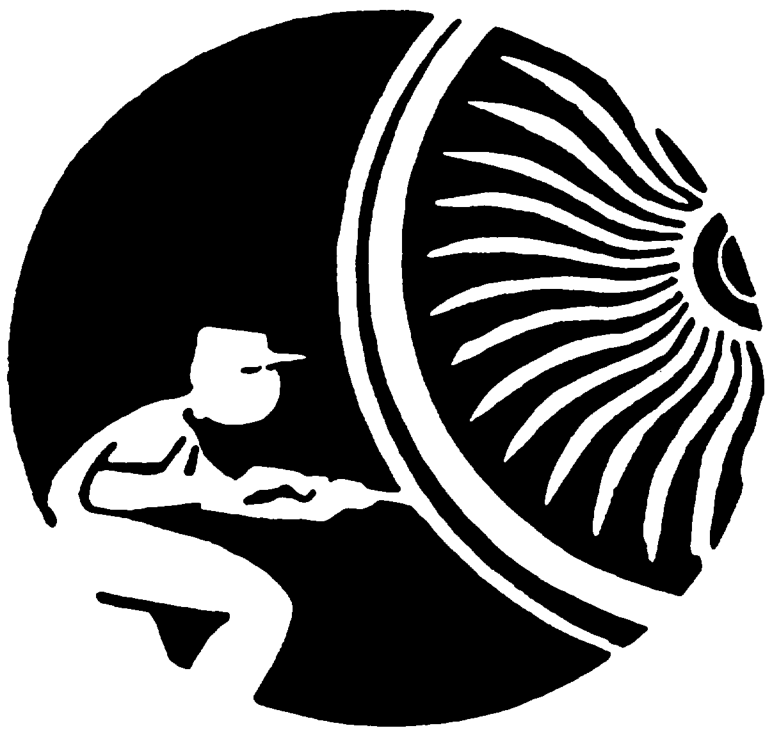
U.S. Department
of Transportation

Federal Aviation
Administration

Advisory Circular

AC NO.: 43-204
DATE: 8/14/97

VISUAL INSPECTION FOR AIRCRAFT



Initiated By: AFS-350

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1. PURPOSE. This advisory circular (AC) provides technical information to persons conducting a visual inspection of aircraft. The procedures presented in this AC are an acceptable means, but not the only acceptable means, for conducting visual inspections and inspection programs. Where the aircraft, engine, propeller, or appliance manufacturer has published a recommended inspection schedule or program for a particular aircraft, that program should take precedence over the recommendations of this AC.

2. RELATED READING MATERIAL.

a. AC 20-37D, Aircraft Metal Propeller Maintenance.

b. AC 43-3, Nondestructive Testing in Aircraft.

c. AC 43-4A, Corrosion Control for Aircraft.

d. AC 43-7, Ultrasonic Testing for Aircraft.

e. AC 43-12A, Preventive Maintenance.

f. AC 43.13-1A, Acceptable Methods, Techniques and Practices--Aircraft Inspection and Repair.

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Acting Deputy Director, Flight Standards Service

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CHAPTER 1. GENERAL

1. INTRODUCTION. Over 80 percent of the inspections on large transport category aircraft are visual inspections.[1] On small transport aircraft the ratio is even greater and on general aviation aircraft, virtually all inspection is visual. Visual inspection is usually the most economical and fastest way to obtain an early assessment of the condition of an aircraft and its components. Most of the defects found on aircraft are found by visual inspections, and the airframe manufacturers and users depend on regular visual inspections to ensure the continued airworthiness of their aircraft. Consequently, it is important that visual inspection methods be understood and properly applied by those responsible for the continued airworthiness of aircraft. Proficiency in visual inspection is crucial to the safe operation of aircraft. Such proficiency is gotten from experience, but also by learning the methods developed by others. This document describes those methods and the way they are used in the various inspections carried out on aircraft.

2. RELATION OF VISUAL INSPECTION TO NONDESTRUCTIVE INSPECTION (NDI). Visual inspection is an essential part of airplane maintenance. The visual inspection component of NDI requires trained and experienced inspection personnel, using validated procedures and appropriate calibration standards with effective, well-maintained equipment in a well-managed maintenance environment.

3. DEFINITION OF VISUAL INSPECTION. Visual inspection is defined as the process of using the eye, alone or in conjunction with various aids, as the sensing mechanism from which judgments may be made about the condition of a unit to be inspected. Imaging devices are playing an increasing part in the inspection process, (e.g., ultrasonic C-scans, eddy current imaging, real-time X ray). Analysis of such displays is not considered visual inspection and will be covered under image analysis in AC 43-X, Nondestructive Inspection For Aircraft.

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[1] Goranson, U.F. and Rogers, J.T., "Elements of Damage Tolerance Verification," 12th Symposium of International Commercial Aeronautical Fatigue, Touluse, France, May 1983.

4. PURPOSE OF VISUAL INSPECTION.

Visual inspection is used to:

- Provide an overall assessment of the condition of a structure, component, or system.

- Provide early detection of defects before they reach critical size.

- Detect errors in the manufacturing process.

- Obtain more information about the condition of a component showing evidence of a defect.

In many situations, no reliable alternative exists to visual inspection. Visual procedures are mandated by the FAA for structural inspections to support Supplementary Structural Inspection Documents (SSIDs), Service Bulletins (SBs), and Airworthiness Directives (ADs).

5. AIRFRAME AND ENGINE STRUCTURAL DETAILS.

a. Typical Airframe Defects. Typical airframe defects found in aircraft which can be detected by visual inspection can be divided into three types: cracks, corrosion, and disbonding. Other defects, such as system and component wear, accidental damage, environmental damage from long term storage, sunlight, etc., can also be detected visually.

(1) Cracks. Figure 1-1 illustrates areas most susceptible to cracks. Figure 1-2 shows typical surface cracks which can be detected by visual inspection. Surface cracks caused by fatigue are illustrated in Figure 1-3. An example of skin-cracking at fasteners is shown in Figure 1-4. Sometimes an underlying crack can cause a distortion which can be detected visually.

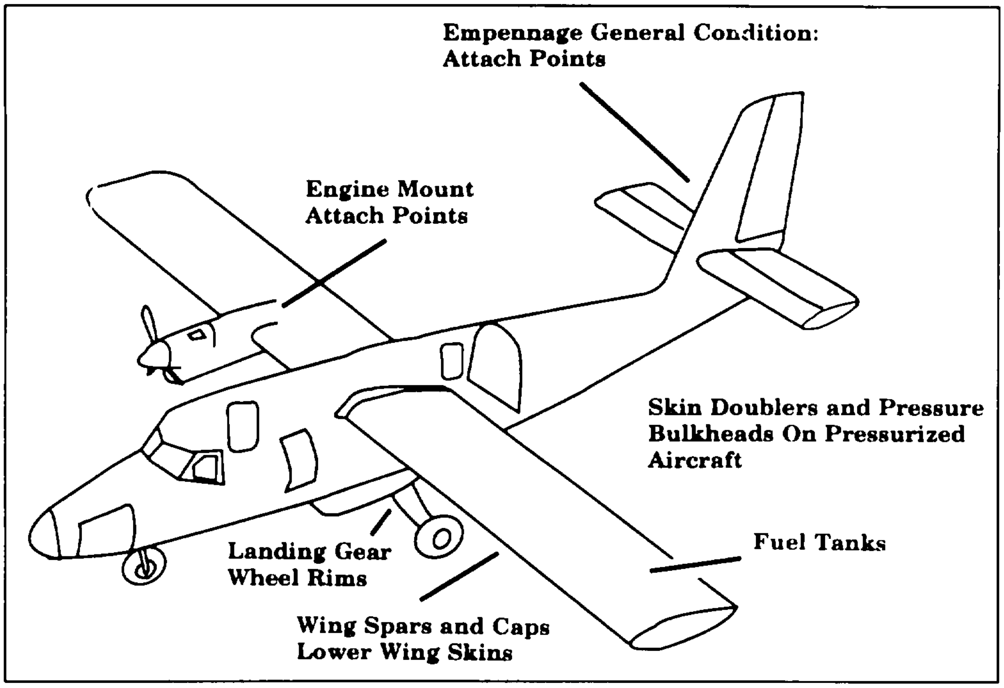

FIGURE 1-1. AREAS MOST SUSCEPTIBLE TO CRACKS

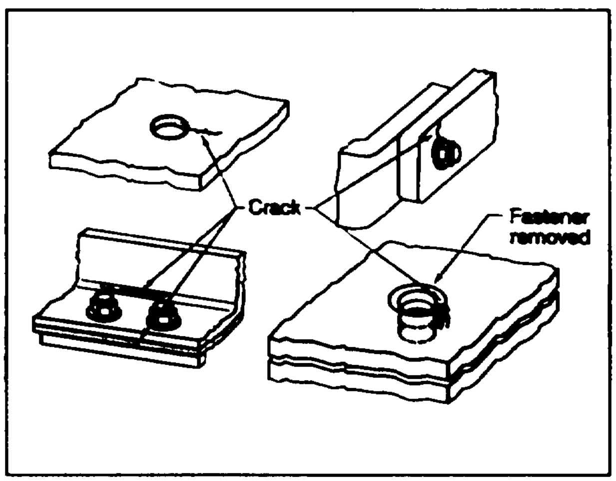

FIGURE 1-2. TYPICAL SURFACE CRACKS

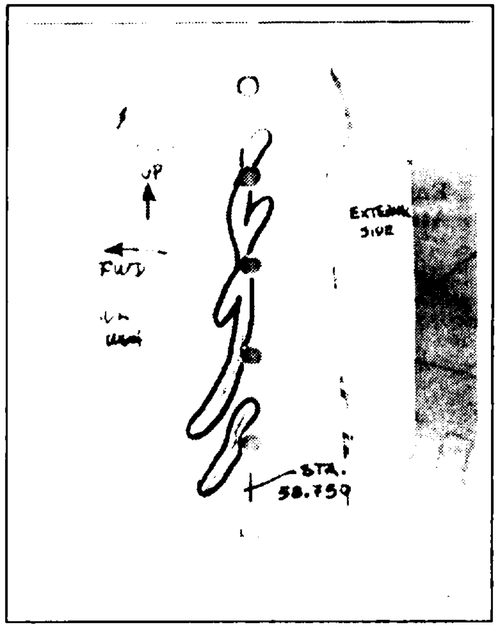

FIGURE 1-3. MULTIPLE-SITE DAMAGE SURFACE FATIGUE CRACKS

FIGURE 1-4. EXAMPLE OF SKIN-CRACKING AT FASTENERS

(2) Corrosion. Figure 1-5 illustrates areas most susceptible to corrosion. The various manifestations of corrosion such as missing rivet heads are shown in Figure 1-6.

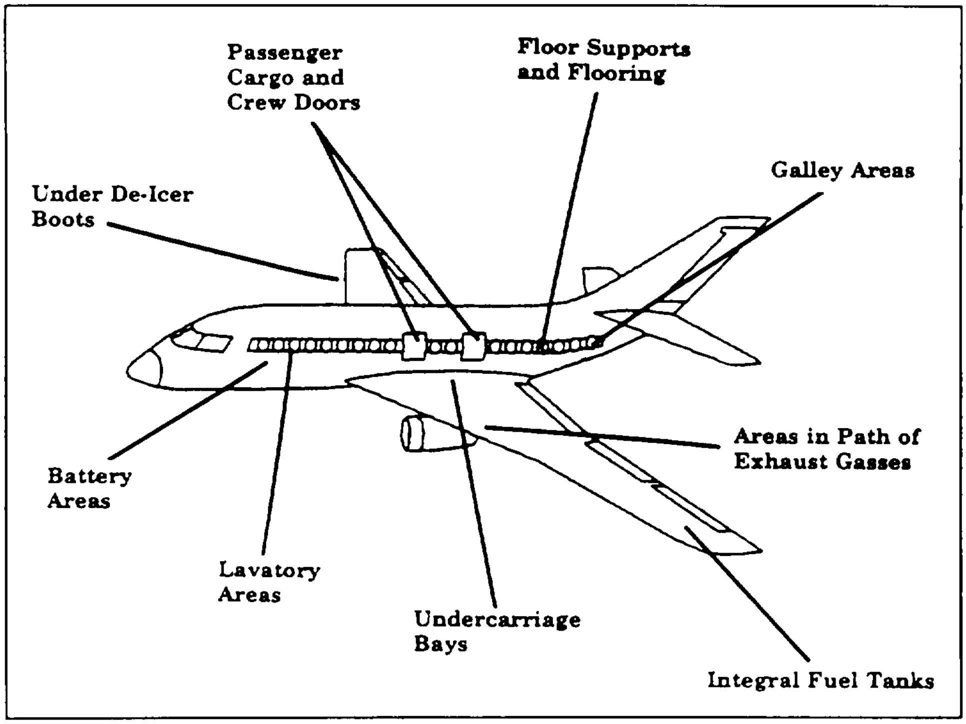

FIGURE 1-5. AREAS MOST SUSCEPTIBLE TO CORROSION

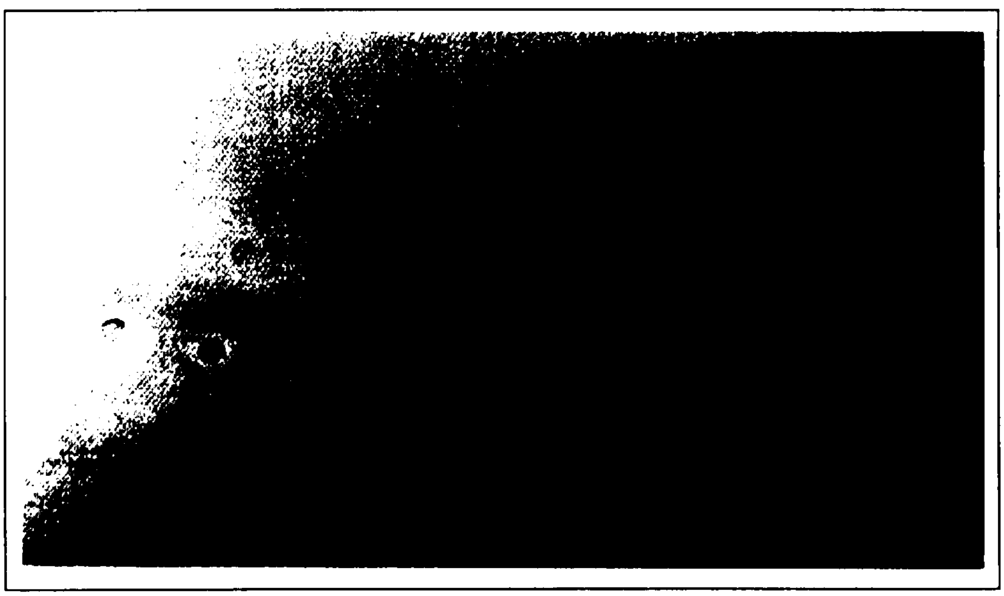

FIGURE 1-6. EXAMPLE OF MISSING RIVET HEADS RESULTING FROM CORROSION PRODUCTS

An example of blistering of paint in a fuel cell caused by corrosion is illustrated in Figure 1-7. Chipped and loose paint on a wing skin is shown in Figure 1-8. Figure 1-9 shows internal corrosion of a tubular engine mount.

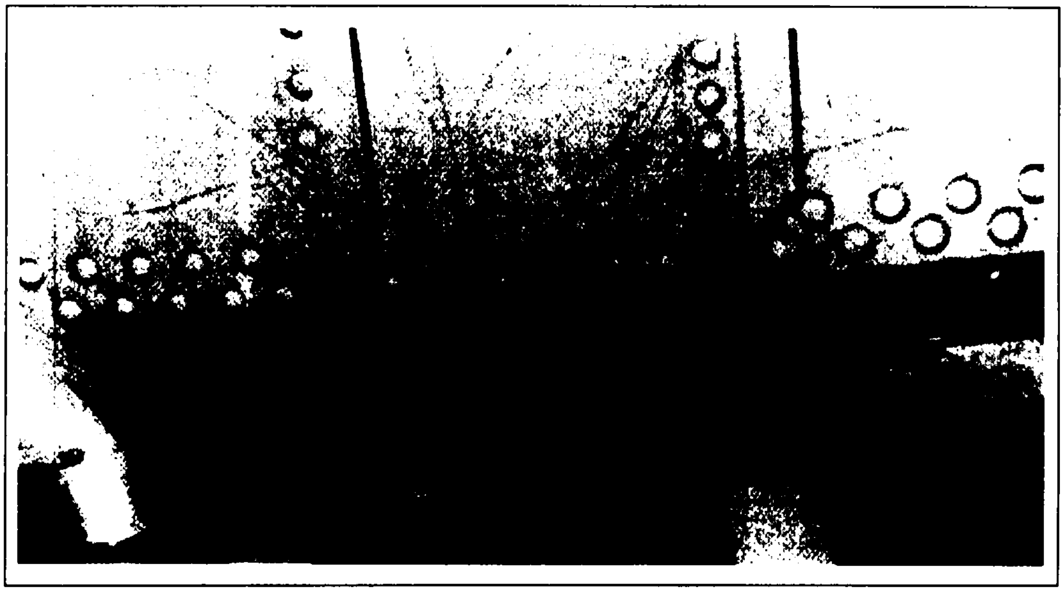

FIGURE 1-7. EXAMPLE OF BLISTERING OF SEALANT IN A FUEL CELL CAUSED BY CORROSION

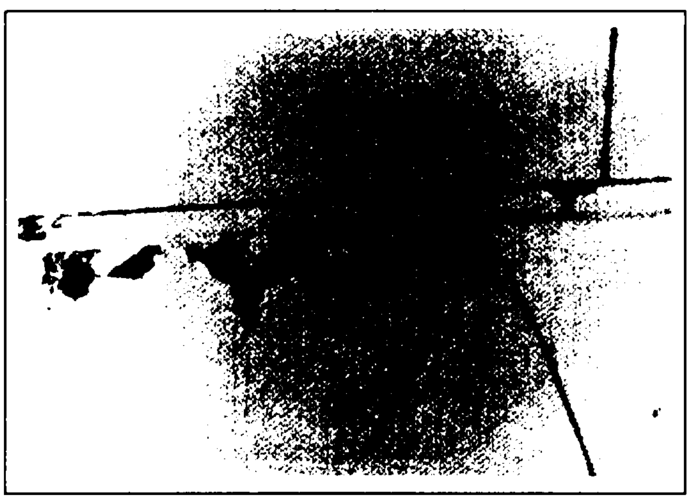

FIGURE 1-8. EXAMPLE OF CHIPPED AND LOOSE PAINT ON A WING SKIN CAUSED BY CORROSION

FIGURE 1-9. INTERNAL CORROSION OF THE TUBULAR ENGINE MOUNT OF A 1946 VINTAGE CESSNA
(Courtesy of Shoreline Aviation, Marshfield Municipal Airport, MA)

Corrosion of a rudder control cable and elevator rib are shown in Figures 1-10 and 1-11, respectively. Figure 1-12 shows an example of skin-bulging from corrosion of the faying surface between skin and internal structure around a cargo doorway. Figure 1-13 shows two examples of a nut which cracked from corrosion fatigue. Figure 1-14 illustrates landing gear and wheel corrosion points.

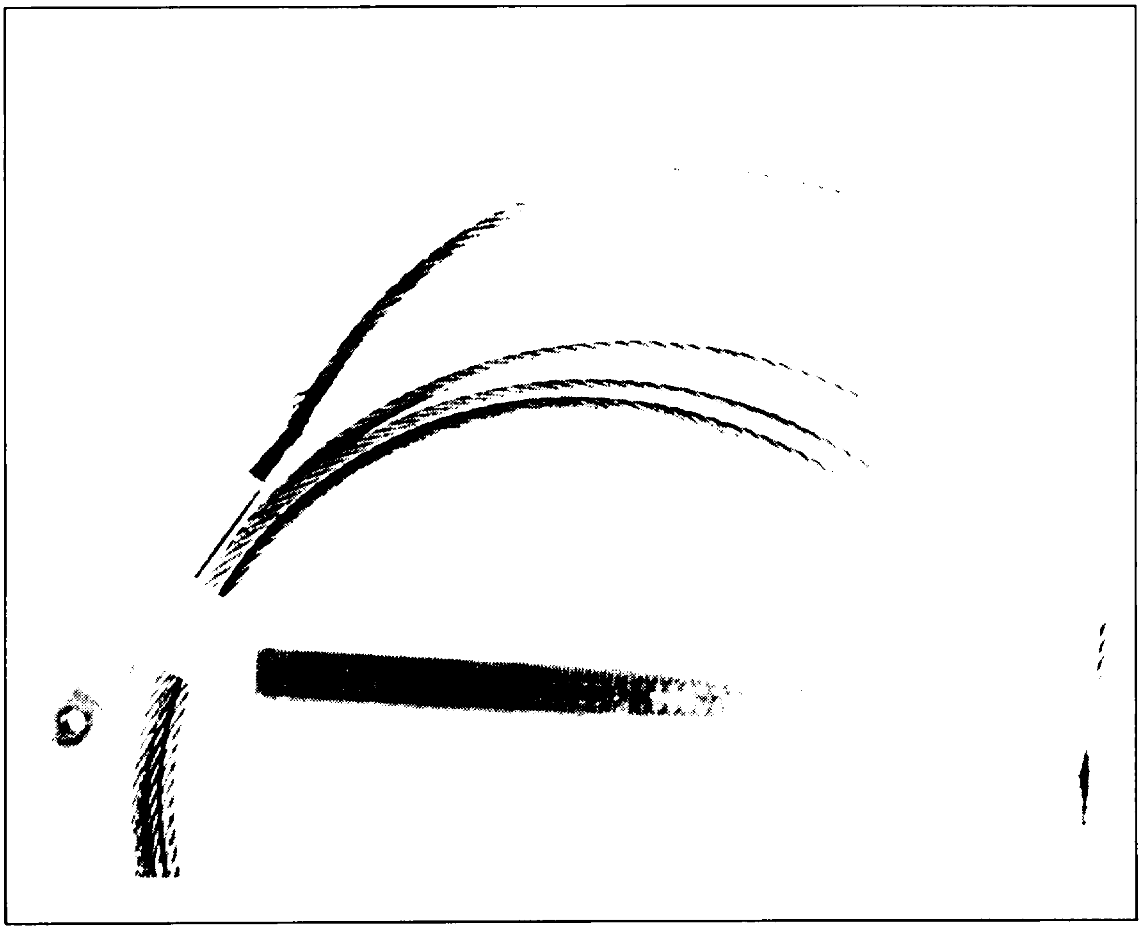

FIGURE 1-10. CORROSION OF THE RUDDER CONTROL CABLE OF A 1969 CESSNA 172, FOUND VISUALLY (Courtesy of Shoreline Aviation, Marshfield Municipal Airport, MA)

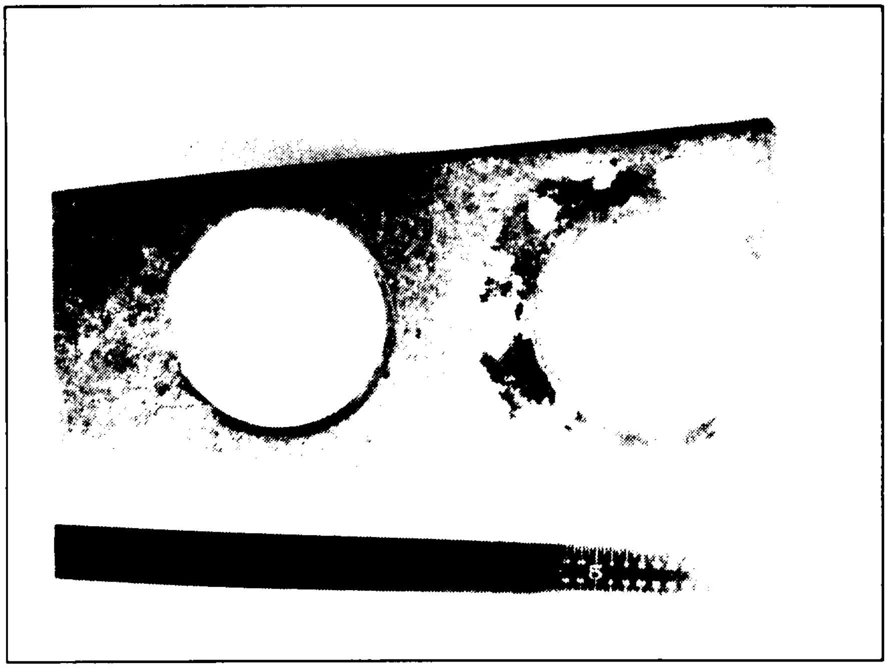

FIGURE 1-11. CORROSION OF THE ELEVATOR RIB OF A 1969 CESSNA 172, FOUND VISUALLY (Courtesy of Shoreline Aviation, Marshfield Municipal Airport, MA)

FIGURE 1-12. EXAMPLE OF SKIN-BULGING DUE TO CORROSION

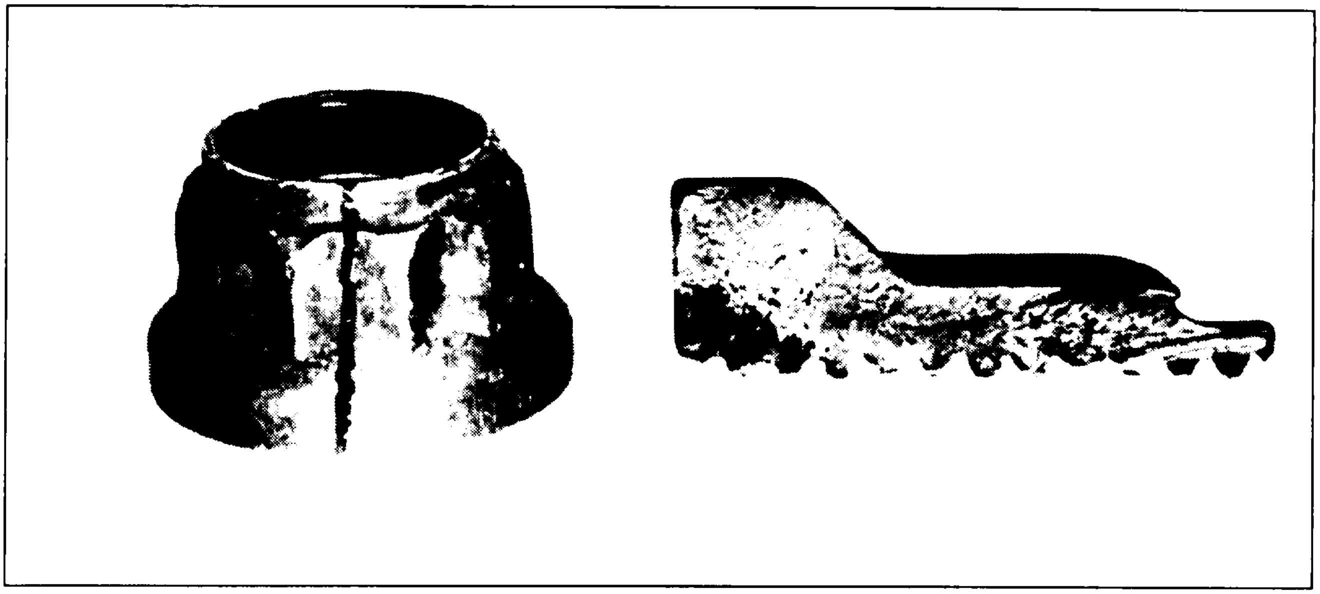

FIGURE 1- 13. EXAMPLE OF CRACKED NUT DUE TO CORROSION
(Courtesy of McDonnell Douglas)

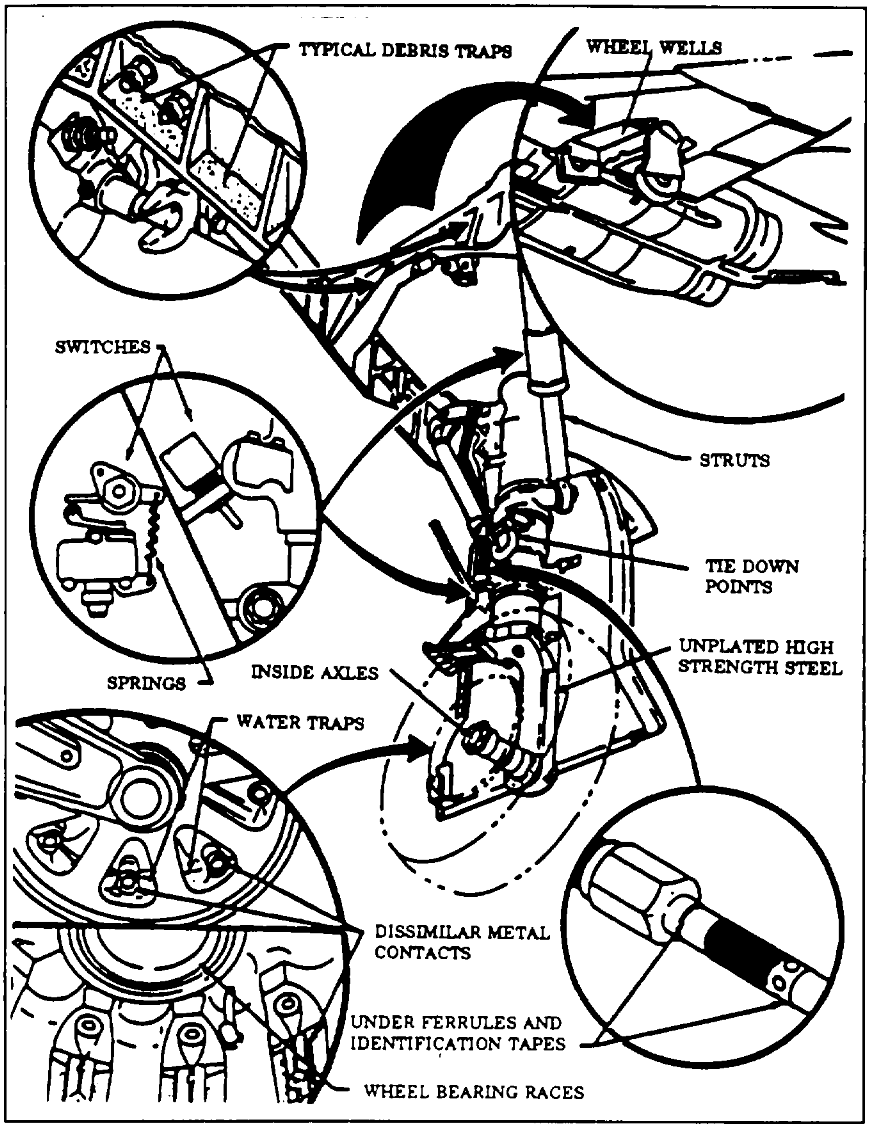

FIGURE 1-14. LANDING GEAR AND WHEEL CORROSION POINTS
(Courtesy of the U.S. Navy)

(3) Disbonding. It is very difficult to detect disbonding by visual means, since it is usually an internal condition and not likely to show up on the surface of an aircraft. Figure 1-15 illustrates areas most susceptible to disbonding. Wherever a bonded surface becomes disbonded, corrosion is likely to occur and may be detected visually.

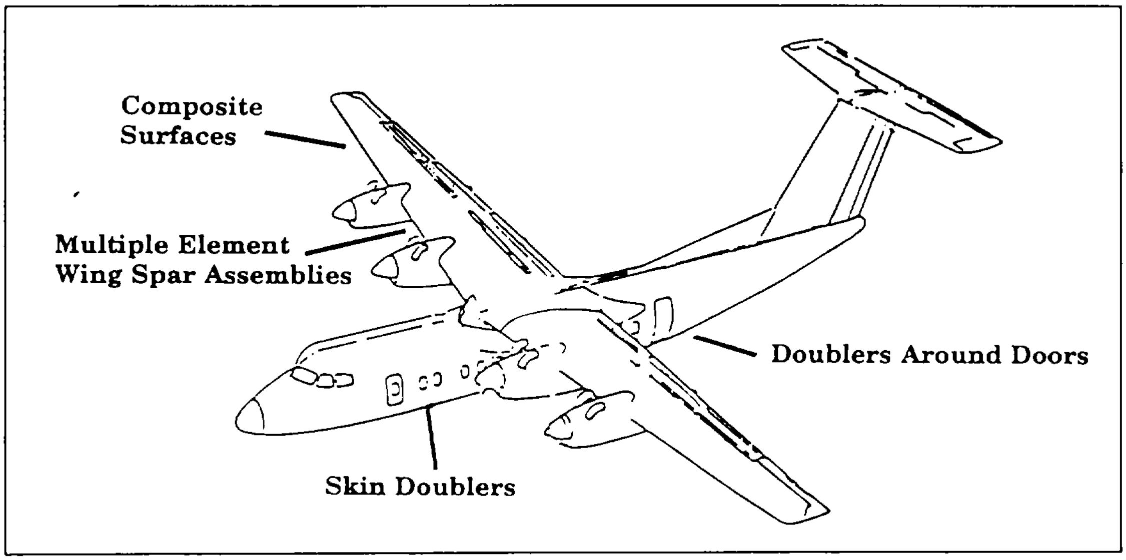

FIGURE 1-15. AREAS MOST SUSCEPTIBLE TO DISBONDING

b. Engine Defects. Figure 1-16 shows typical defects found during inspection of engine components. Frequently it is necessary to use visual aids to detect defects. Figure 1-17 illustrates typical defects seen through borescopes and other aids.

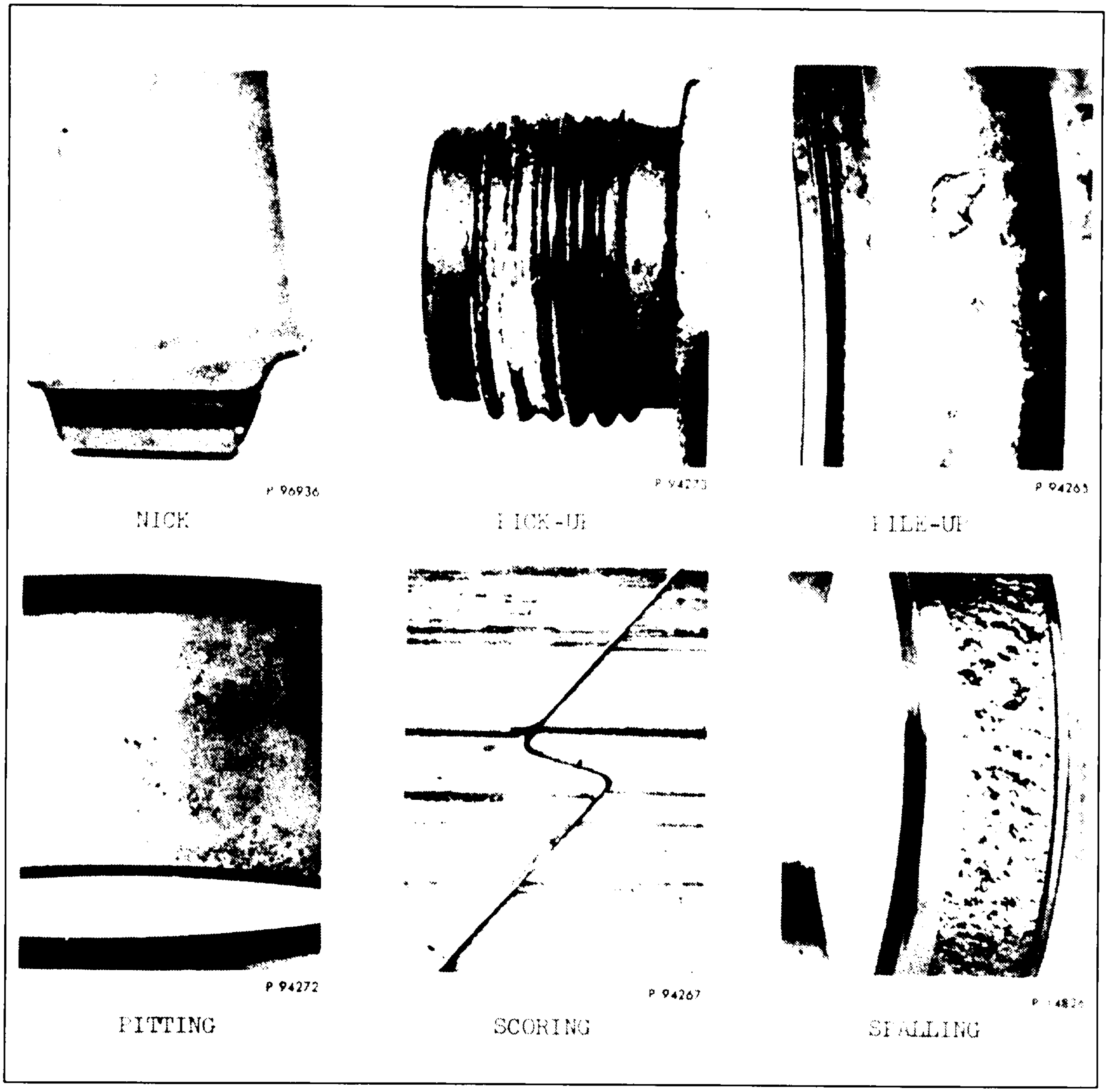

FIGURE 1-16. COMMON PHYSICAL CHARACTERISTICS OF ENGINE DEFECTS
(Sheet 1 of 3)
(Courtesy of Pratt & Whitney)

BLISTERING

BRINELLING

BURNING

BURNING

CHIPPING

CORROSION

CRACK

CRACK

EROSION

FIGURE 1-16. COMMON PHYSICAL CHARACTERISTICS OF ENGINE DEFECTS (Sheet 2 of 3)

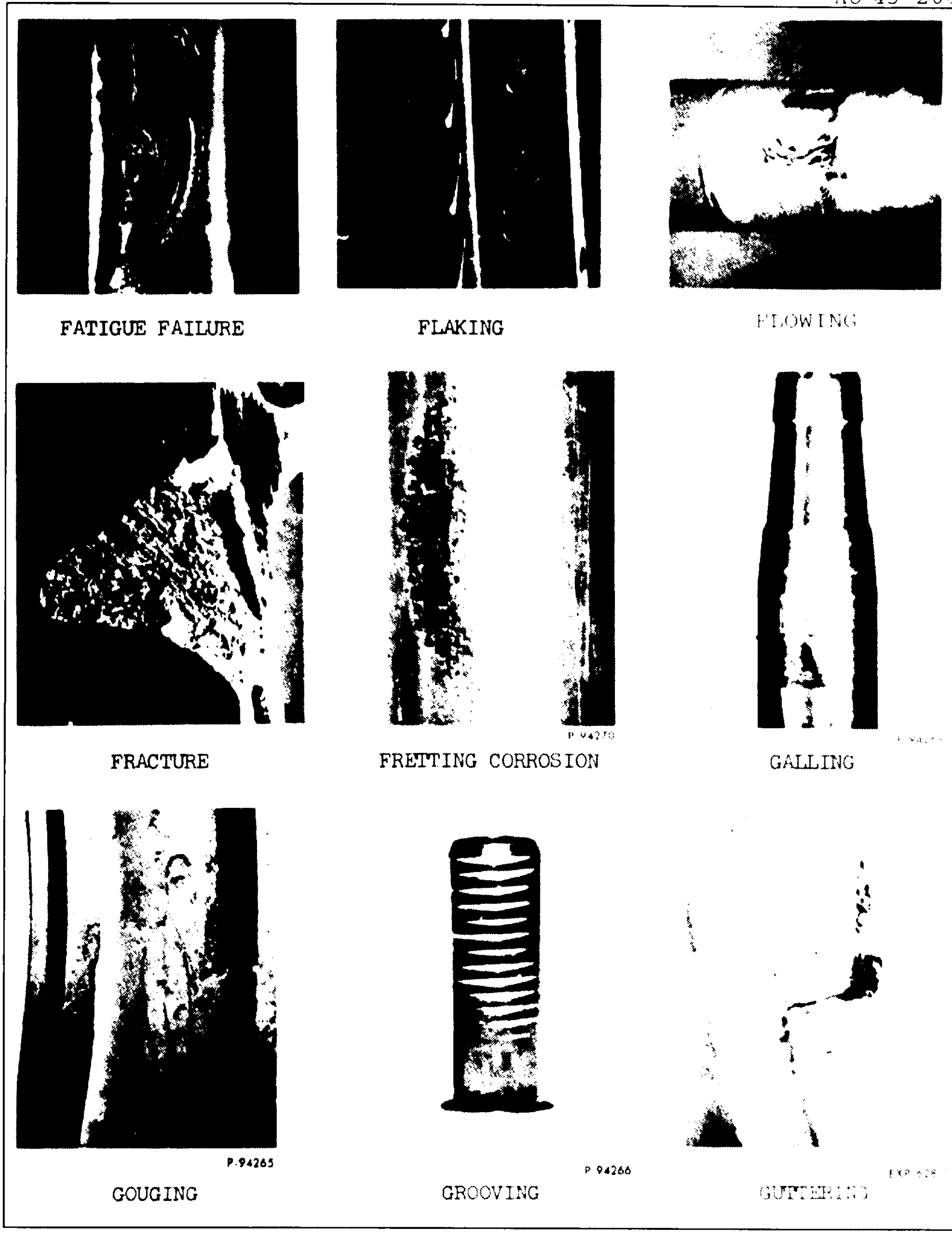

FIGURE 1-16. COMMON PHYSICAL CHARACTERISTICS OF ENGINE DEFECTS
(Sheet 3 of 3)

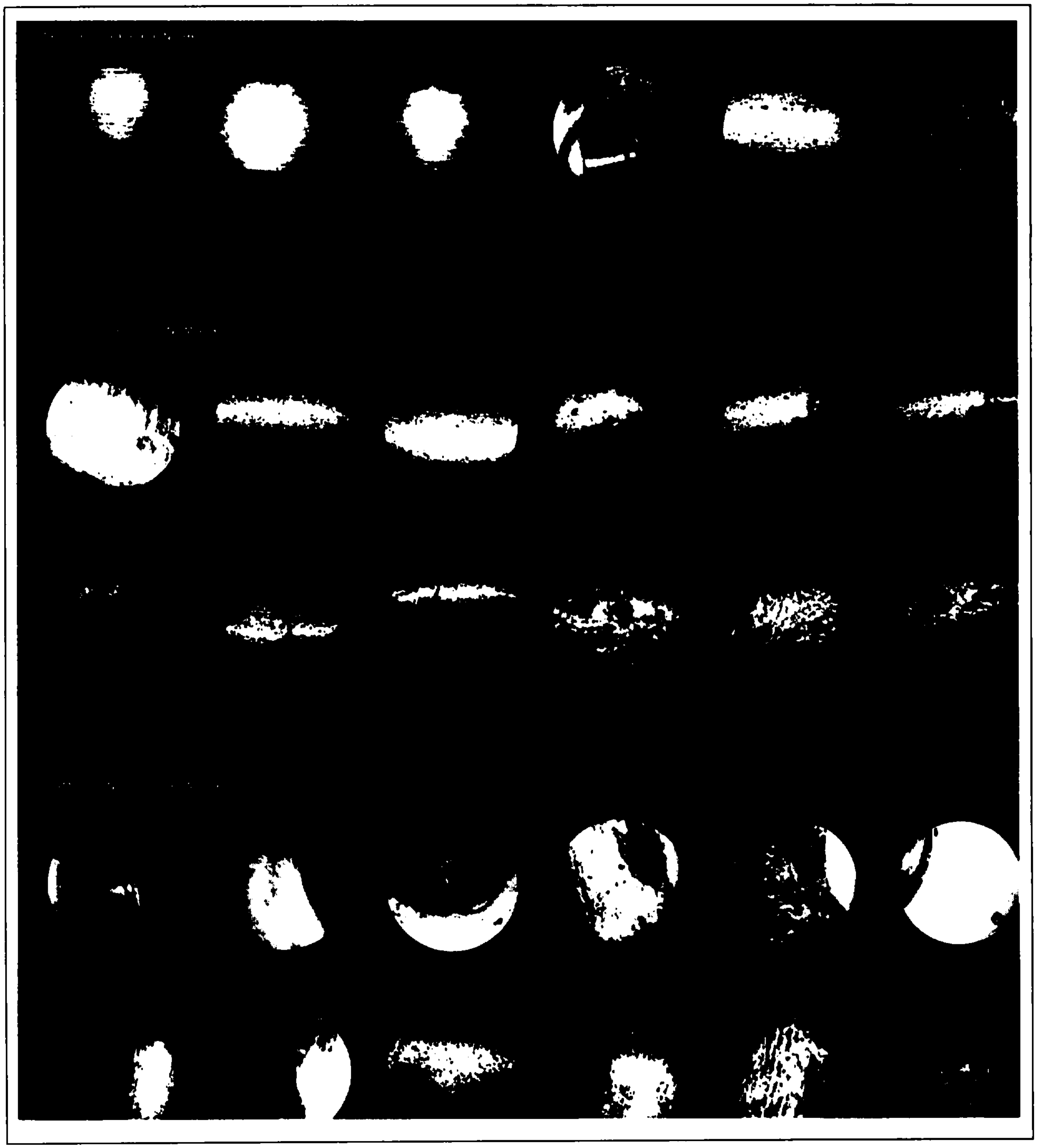

FIGURE 1-17. TYPICAL DEFECTS AS SEEN THROUGH BORESCOPE AND OTHER AIDS
(Courtesy of McDonnell Douglas)

6. <u>FACTORS AFFECTING VISUAL INSPECTION</u>. Any factor that aids visual effectiveness increases the probability of detecting the potential cause of a failure and subsequent corrective action.

a. <u>Inspection Personnel Qualifications and Training</u>. Inspection personnel should posses experience and knowledge of the origins and causes of defects in raw material manufacturing processes, the reshaping and redistribution of these defects in subsequent part manufacturing processes, and defects that develop after the part is put in service. Inspection personnel should also have a working knowledge of the part, component, or aircraft being inspected. It is essential that inspection personnel be knowledgeable concerning the structural detail being evaluated to enable them to properly locate, identify, and evaluate aircraft defects. Persons who inspect, approve, and return to service an aircraft appliance or part, must be certified in accordance with the appropriate FARs or perform the work under a certificate holder who is directly in charge of that person.

b. <u>Inspection Area Access</u>. Ease of access to the inspection area is important in obtaining reliable visual inspection results. Access consists of the act of getting into an inspection position (primary access) and performing the visual inspection (secondary access). Unusual positions (i.e., crouching, lying on back, and overhead reaching) constitute examples of difficult access.

(1) <u>Impact on Inspection</u>. The necessity to get both hands into the aircraft structure while holding a flashlight or mirror or reaching into awkward openings can affect the inspector's motivation, attitude, decision-making, and ability to interpret what is seen.

(2) <u>Access and Safety</u>. Staging equipment (e.g., platforms, ladders, stools) used to permit access to the airframe and engines should be used safely, i.e., secured manually or brake engaged to prevent slips and falls. Protection should be provided to prevent potential injury from sharp edges and shifts in heavy weights. Adequate protection from falls should be provided wherever possible, such as railings and harnesses and lanyards on high working platforms.

c. <u>Lighting</u>. Adequate quality and intensity of illuminance and elimination of direct glare, reflected glare, and harsh shadows all enhance the identification of defects. Conversely, excessive visual fatigue and the delayed eye adaptation experienced when moving from bright surroundings into dark ones and vice versa could reduce effective detection of defects.

(1) <u>Localized Illumination</u>. Illumination should be provided during occupancy of spaces that possess limited access. In

those areas which do not have fixed lighting, portable and vehicle-mounted lighting equipment should be used.

(2) Excessive Glare. Uncontrolled large differences of illumination and excessive glare should be avoided. Appropriate guides to limiting glare and adaptation effects are discussed in Chapter 3 of this AC and in the Illumination Engineering Society (IES) handbooks on lighting.

(3) Lighting and Safety. Some accidents which have been attributed to an individual's carelessness could have been partially due to poor lighting. Illumination levels regarded as absolute minimums for safety alone have been developed by the IES and are listed in Table 1-1.

TABLE 1-1. ILLUMINANCE LEVELS FOR SAFETY*

HAZARDS REQUIRING VISUAL DETECTION	SLIGHT		HIGH	
Normal** Activity Level	Low	High	Low	High
Illuminance Levels (Footcandles)	0.5	1	2	5

* Minimum illuminance for safety of people, absolute minimum at any time and at any location on any plane where safety is related to seeing condiions.

** Special conditions may require different illuminance levels. In some cases higher levels may be required, as for example where security is a factor. In some cases greatly reduced levels, including total darkness, may be necessary, specifically in situations involving manufacturing, handling, use, or processing of light-sensitive materials (notably in connection with photographic products). In these situations alternate methods of insuring safe operations should be relied upon.

NOTE: See specific application reports of the IES for guidelines to minimum illuminances for safety by area.

d. Precleaning. It is necessary for parts to be inspected to be free from dirt, contamination, or anything which would tend to obscure detection of important defects. It is also important during cleaning not to remove or obscure evidence of a defect. For example, cracks may become hidden by abrasive treatment and rendered invisible.

e. Working Environment Factors. Excessive temperature, wind, rain, and other climactic factors tend to adversely affect inspections. Excessive noise tends to reduce concentration, create tension, and prevent effective communication. These conditions increase the likelihood of errors, degrade reliability, and potentially impact personnel safety. The FAA's human factors research program addresses many factors which affect the reliability of visual inspection.[2]

7. SAFETY.

a. General Safety. Safety hazards which could cause injury to the inspector or prevent the identification of defects should be eliminated or minimized.

b. Safety Instructions for Inspection Systems and Materials. The operating safety instructions of the manufacturers of the inspection systems and materials should be followed. The eye can be harmed by intense lighting and lasers (which have their own associated safety regulations and precautions). The various materials used for cleaning in preparation for visual inspection may contain chemicals which, if improperly used, can be hazardous to the health and safety of operators. Safe handling of cleaning materials is governed by the suppliers' Material Safety Data Sheets (MSDSs). MSDSs, conforming to 29 CFR 1910.1200, or equivalent, should be provided by the supplier to any user and should be prepared in accordance with FED-STD-313. Flammable or combustible cleaners and chemicals should be kept in approved safety containers and only in minimum quantities. Some cleaners and chemicals may have an adverse effect on skin, eyes, and respiratory tract. Manufacturers' warning labels and current safety directives should be observed. Cleaners and chemicals should be used only in authorized areas. Soiled flammable or combustible cloths should be discarded into covered metal containers.

8. THE VISUAL INSPECTION PROCESS. The process of visual inspection should contain two fundamental elements to be successful: (1) a trained inspector with binocular vision and good visual acuity; (2) an inspection procedure which defines the details of the inspection, including examples of the defect(s) tracked. This document presents examples of these elements and their interrelation in aircraft inspection. The findings of qualified inspectors using appropriate procedures on specific details of an aircraft can be analyzed to provide quantitative data on the reliability of inspection for a given detail. Knowledge gained from this analysis establishes the time intervals at which the inspections are performed.

a. Procedures and Processes for Visual Inspection. The various components of a modern aircraft vary depending upon their use, material makeup, method of fabrication, and the environment in which they operate. While most of the aids for the inspection

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[2] Office of Aviation Medicine Reports: Human Factors Issues in Maintenance and Inspection, 1994.

process are used for engines, airframes, related systems, components, and accessories, they are used to a differing degree and may be modified and configured for specific applications. The major difference between inspection of engines and airframes is that only cursory inspections of engines can be made on the aircraft. Although borescopes and other enhancements are expanding the number and quality of inspections on mounted engines, complete and rigorous engine inspections necessitate their removal from the aircraft and, in many cases, full teardown.

b. Generalized Techniques. Successful visual inspections on any type of structure usually embody known techniques and procedures which have been developed by experience. Examples of such techniques are described in Section 9.

c. Specific Techniques. There are specific techniques for detecting defects unique to airframes and engines. Specific guidelines and techniques used for inspection of airframes and engines are described in Sections 10 and 11, respectively.

9. VISUAL INSPECTION, GENERAL. To conduct an effective visual observation, inspection personnel should not only look at an object, but examine it based on their knowledge of it and established rules.

a. Targets. Effective inspectors look at specific targets rather than scan an area. The eye is functionally blind when it is moving between observation points. Accordingly, a procedure of step-scanning is used. Lookouts spotting objects on the horizon are taught to step-scan with binoculars. Those who are proficient can detect approaching objects long before they are otherwise visible. Similarly, when observing dim objects against a dark background, observers are taught to focus to one side or above the object viewed. They are then able to see details which are not otherwise visible. These and other types of methods can be used by inspectors to look for target defects in all parts of the aircraft.

b. Imagination. Another useful technique for the inspector is to imagine what type of action would cause a particular defect. This thought process may provide a clue as to what the defect will look like. Skin wrinkles, which may be caused by an underlying crack, are an example of a defect identified by such a process.

c. Markings. Markings or anomalous concentrations of discoloration may signal the presence of a defect. When smoking was permitted on aircraft, inspectors knew that nicotine smears were associated with skin cracks. Close inspection is still necessary where concentrations of contaminants and discoloration occur, since they may signal the existence of crack sites. Scratches, marks, and other anomalous features on the area inspected inform the trained inspector and are used to detect defects which may affect airworthiness. Loose rivets tend to emit "smoke", discoloration, and streaking (localized).

d. Corrosion. Corrosion is primarily detected by visual inspection. Since its detection is critical, inspection personnel should be familiar with the appearance of the common types of corrosion and have training and experience in corrosion detection on aircraft structural and engine materials. Corrosion Control for Aircraft (AC 43-4A) contains technical information on corrosion identification, photos illustrating examples of typical corrosion, and guidance on treatment of corrosion on aircraft structural, engine, and related materials. It may be necessary to remove corrosion to assess the condition of the underlying material. It is important not to destroy the surface finish, or remove protective coatings which would be difficult to replace, such as the "cladding" found on the skin surface of major transports. In general aviation, an inspector will sometimes probe a part with a center punch in an area of suspected corrosion; if more than a minor indentation is observed, corrosion is present.

e. Inspection After Maintenance. After a component has been serviced, repaired, or otherwise maintained, it should be inspected for abnormalities. A similar inspection of the surroundings should be carried out when a component or accessory is reinstalled in the aircraft. Look for loose material, missing coatings, other damage, etc.

10. AIRFRAME VISUAL INSPECTION. It is necessary not only to know how to examine, but where to examine, when inspecting details for defects with which one is familiar from past inspections. The flashlight and the mirror are standard tools which should accompany the inspector on all inspections. The inspector should become skillful in using these tools. Also, magnifiers should be readily at hand for some types of inspections. Other aids which may be available for specialized requirements are described in Chapters 3 and 4. The flashlight/mirror combination can be used to illuminate an area as well as view it and is particularly valuable in inaccessible spots. Magnifiers are invaluable for defining the extent and character of cracks and problems in riveted assemblies.

a. Visual Detection of Surface Cracks. When searching for surface cracks with a flashlight, the light should be directed at a 5- to 45-degree angle (see Figure 1-18). The light beam should not be directed at such an angle that the reflected light beam shines directly into the eyes. The eyes should be focused above the beam during the inspection. The extent of any cracks can be determined by directing the light beam at right angles to the crack and tracing its length. A 10-power magnifying glass should be used to confirm the existence of a suspected crack. If this is not adequate, other NDI techniques—such as penetrant, magnetic particle, or eddy current—may be used to verify cracks.

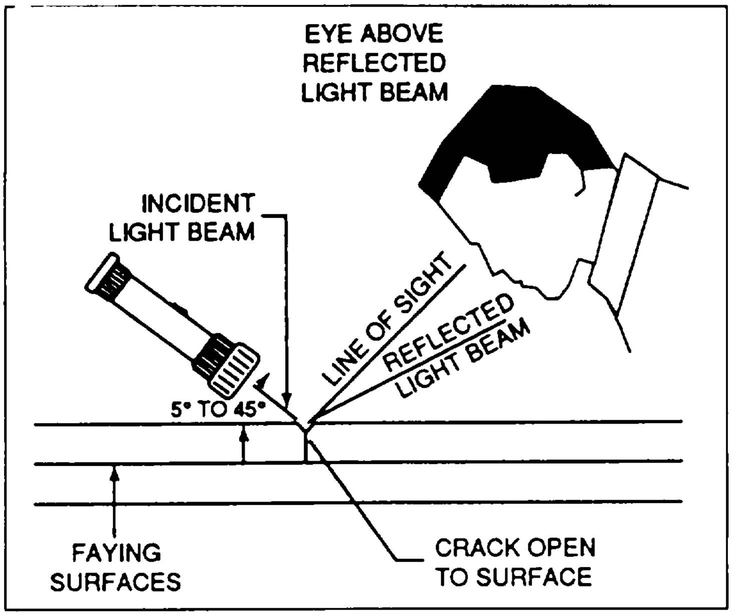


FIGURE 1-18. USING A FLASHLIGHT TO INSPECT FOR SURFACE CRACKS

b. Visual Detection of Hidden Defects. The mirror can be used with great effect in locations that cannot be viewed directly. The mirror is frequently attached to a long arm so that it can be directed around corners. It is frequently necessary to shine a light onto the mirror and indirectly illuminate the area requiring or undergoing inspection.

c. Hardware and Fasteners. Rivets, bolts, and other miscellaneous structural hardware should be inspected for looseness, integrity, proper size and fit, and corrosion. Dished, cracked, or missing rivet heads and loose rivets should be identified and recorded, using the arsenal of visual inspection techniques available. The inspector should ensure that sufficient light is available to be able to really see every fastener. Once again, a flashlight is indispensable.

d. Control Systems. Cables, control rods, rod ends, fairleads, pulleys, and all other similar items should be examined for integrity, structural soundness, and corrosion.

e. Visual Inspection for Corrosion. Inspection of an aircraft for corrosion follows a systematic pattern.

(1) Clues. The aircraft is initially observed for clues as to the care with which it has been maintained. Have obvious

corrosion control measures been taken? Have drains been cleaned, paint replaced, and debris removed?

(2) Locations. Inspect likely corrosion sites. These include galleys and food service areas, lavatories, bilges, tank drains, and fastenings. When debris is found, it should be examined for iron oxide and the characteristically white powdery aluminum hydride. Biological contamination (mold, algae), which may feel greasy or slippery, frequently causes corrosion since it alters the acidity of any moisture it contains. Caulking and sealing compounds should be tested for sound adhesion since corrosion can intrude under such materials. Nutplates should be investigated for underlying corrosion. Tap tests should be performed frequently and any dull sounding areas investigated carefully. The use of a center punch or awl to indent a surface should be used with care, since awl or center punch pricks can serve as sites for the initiation of fatigue cracks. The omission of fuel additives by some fuel vendors can accelerate the deterioration of tankage on small aircraft. In such cases, it is necessary to drain tanks and inspect them using lighted borescopes or other aids. Flight and control surfaces are difficult to inspect since access is difficult. Extensive use of aids is recommended for such locations.

(3) Sites. Careful detailed examination of corrosion sites is then accomplished to define the extent of corrosion. This can lead to removal of skin panels or other measures to further define the extent of damage.

f. Disbonds. Many aircraft have extensive regions of adhesive bonding of the structure alone or in combination with rivets. It is frequently necessary to detect disbonds and adhesive failure in structure. It should be remembered that, in adhesively bonded structures, evidence of corrosion frequently signals the loss of bond integrity. A good example of this condition is the pillowing which appears behind rivets. If the structure is bonded as well as riveted, one can be sure that where pillowing exists the bond is destroyed. Unfortunately, the reverse is not also true. It is quite possible for an uncorroded joint to be disbonded. Frequently, the only means for detecting such a disbond is to mechanically distort the structure and determine whether any adhesion exists in the area of interest. Specifically, the waffle doublers, which act as tear preventers in pressurized aircraft, should be tested where possible.

g. Painted Surfaces. Painted surfaces should be inspected for chipped, missing, loose or blistered paint and for evidence of corrosion. Refer to AC 43-4A for examples of corrosion.

h. Windshields and Ports. Transparent surfaces—such as windshields, windows, and ports—should be inspected for cracks, crazing, and seeds using a Larascope or similar device. This device uses a plastic prism to permit viewing the interior of transparent plastic or glass window material. The prism is optically coupled to the window being inspected by use of an oil couplant, enabling the operator to see inside the glass. The prism can be manipulated to observe if any cracks are emanating from drill holes or from edges of the transparent material.

i. Other Surface Discontinuities. Other surface discontinuities—such as discoloration from overheating; buckled, bulging, or dented skin; cracked, chafed, split, or dented tubing; chafed electrical wiring; delaminations of composites; and damaged protective finishes—may be found by careful visual inspection.

11. ENGINE VISUAL INSPECTION. Some superficial clues to engine condition are leaks and evidence of smoke. Details observed in engine inspection which differ from airframe inspection generally relate to surface finish and the means for inferring underlying conditions.

a. Forgings, Weldments, Castings, and Machined Parts. The surface texture of the components differs from that of the rolled and formed surfaces most common in airframes. The components are therefore inspected using different criteria. So many engine defects are related to surface features of the material that a glossary of terms is used in most engine manuals to describe visible surface characteristics in terms of the process which caused them and its effect on satisfactory performance of the part. As a result, much of the current guidance relating to engine visual inspection is related to manufacturing processes. This document covers only those visual inspection issues relating to operational and maintenance inspection. The *Engine Visual Inspection Glossary* in this document, however, describes defects which may be found by maintenance inspectors in the field, but are more often found in the manufacturing process rather than "in-service" operations or maintenance.

b. Engine Environment. Another difference related to engine inspection is associated with the environment in which engines are expected to operate. Many engine parts are expected to survive in intense heat. Inspections within the protective enclosures surrounding these areas often require complex visual aids such as light pipes, borescopes, and special inspection fixturing.

12. INSPECTION FOR SPECIFIC TYPES OF CORROSION. This section provides general information for visual inspection of aircraft structure and components for specific types of corrosion. Visual inspection is the primary method for inspecting aircraft structure and components for corrosion. Other NDI techniques such as eddy current, ultrasonic, radiographic, magnetic particle, and penetrant inspection are also used to supplement visual inspection. These other NDI techniques are generally used when costly

disassembly would be required to gain access to hidden structure or components to accomplish visual inspections. They are also used to measure or estimate material loss due to corrosion and to verify the effectiveness of corrosion removal. Inspection of aircraft for corrosion is a continuing requirement and should be done on a daily basis.

a. Corrosion. Corrosion is the electrochemical deterioration of a metal because of its reaction with the surrounding environment. While new and better materials are continuously being developed, this progress is offset, in part, by a more aggressive operational environment. Corrosion is a complex phenomenon which can take many different forms and the resistance of aircraft materials to corrosion can drastically change with only a small environmental change.

b. Catastrophic Corrosion Events. Corrosion is most often thought of as a slow process of material deterioration, taking place over a significant period of time (examples being general corrosion, pitting, exfoliation, etc.). Other forms of corrosion degradation can occur very quickly, in days or even hours, with catastrophic results. These forms (such as stress corrosion cracking, environmental embrittlement, and corrosion fatigue) depend on both the chemical and mechanical aspects of the environment and can cause catastrophic structural failure without warning.

c. Corrosion Occurrence. Corrosion occurs on almost all metals; however, the use of corrosion resistant metals and the application of protective coatings minimize aircraft corrosion. Many other factors contribute to the amount and degree of aircraft corrosion such as the operational environment, materials used in the original design, and the amount of operational preservation provided during maintenance and repair.

d. Aircraft Environment. Aircraft exposed to salt air, heavy industrial pollution, and/or over water operations will experience more corrosion problems than aircraft operated in a dry environment. Corrosion is caused by the presence of salts in moist air or by some other abatement to corrosion present in the chemical content of the water or elements in the metal.

e. Manufacturers' Handbooks. Manufacturers' handbooks should be used as a general guide when an area is to be inspected for corrosion. Some manufacturers have developed videos explaining the process of corrosion and separate corrosion control manuals that are the basis for a complete aircraft corrosion inspection and program. On aircraft for which the manufacturer has not published a recommended corrosion inspection schedule and treatment program, the recommendations of Advisory Circular (AC) 43-4A, *Corrosion Control for Aircraft*, should be followed.

f. Uniform Etch Corrosion. Uniform etch corrosion results from a relatively uniform chemical attack on a metal surface (see Figure 1-19). On a polished surface, this type of corrosion is first seen as a general dulling of the surface, and if the attack is allowed to continue, the surface becomes rough and possibly frosted in appearance.

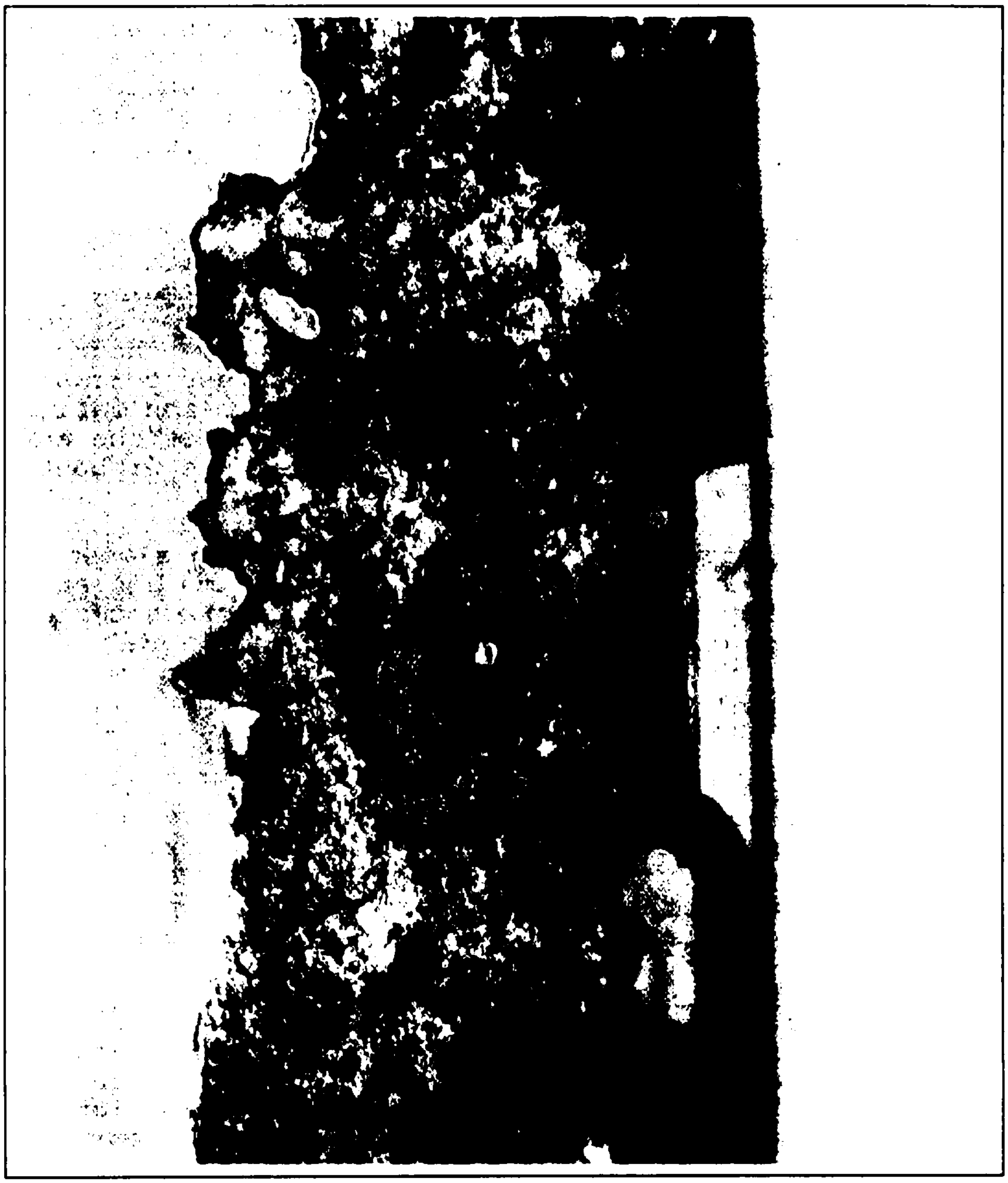


FIGURE 1-19. UNIFORM ETCH CORROSION
(Courtesy of Thomas Flournoy)

g. Pitting Corrosion. The most common form of corrosion on aluminum and magnesium alloys is pitting (see Figure 1-20). It is first noticeable as a white or gray powdery deposit, which, when removed reveals uneven corrosive attack which is revealed as pits or holes in the surface.

FIGURE 1-20. PITTING CORROSION

h. Galvanic Corrosion. Galvanic corrosion occurs when two dissimilar metals make electrical contact in the presence of an electrolyte (see Figure 1-21). The electromotive force (EMF) series lists metals in the order of their ability to corrode as follows.

1. Magnesium Alloys
2. Zinc (plate)
3. Beryllium
4. Cadmium (plate)
5. Aluminum Alloys*
6. Tin (plate)
7. Copper (plate)
8. Nickel (plate)
9. Chromium (plate)
10. Brass (yellow or naval)
11. Bronze
12. Copper
13. Monel
14. Stainless Steels
15. Titanium Alloys
16. Silver
17. Palladium
18. Gold
19. Rhodium
20. Platinum
21. Carbon/Graphite

* 2024 (copper alloys) used mostly in fuselages and the 7000 (zinc alloy) series used mostly in flying and control surfaces have about the same corrosion potential. The exceptions are rolled, extruded, and forged aluminum (anisotropic grain structure) which have been heat treated or cold worked. These alloys are susceptible to exfoliation corrosion.

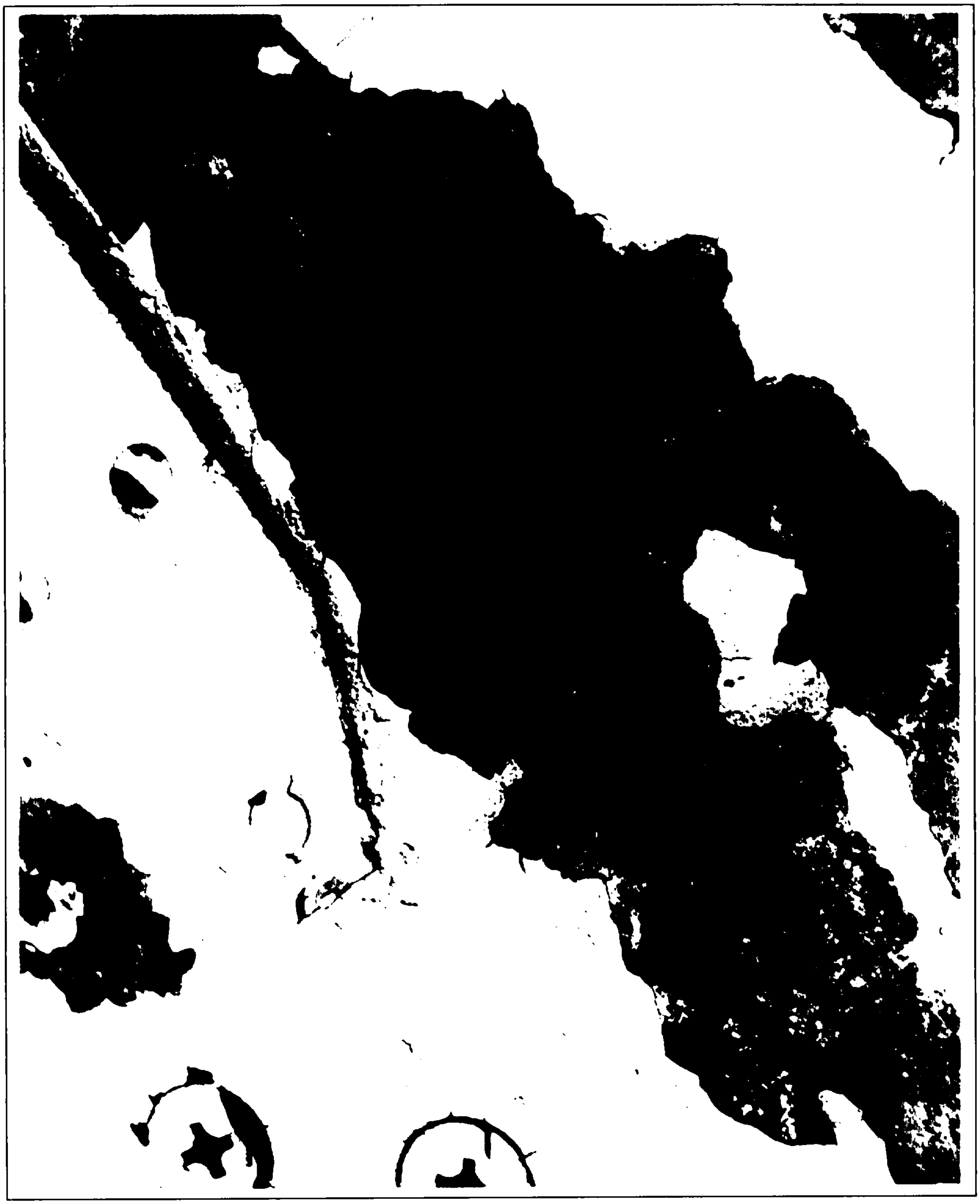


FIGURE 1-21. GALVANIC CORROSION OF MAGNESIUM ADJACENT TO STEEL FASTENER (Courtesy of Thomas Flournoy)

The rate and degree of corrosion depends on the relative surface areas of the two metals and their location on the electromotive force series. Adjacent metals in the EMF series have low corrosion susceptibility whereas widely separated metals will corrode rapidly. For example, an aluminum fastener in contact with a relatively inert Monel (nickel, copper, steel) structure may corrode severely, while a Monel bracket secured to a large aluminum member would result in a relatively superficial attack on the aluminum sheet.

i. Concentration Cell or Crevice Corrosion. Concentration cell corrosion is corrosion of metals in a metal-to-metal joint; corrosion at the edge of a joint, even through joined metals are identical; or corrosion of a spot on the metal surface covered by a foreign material (see Figure 1-22 for the three types of crevice corrosion).

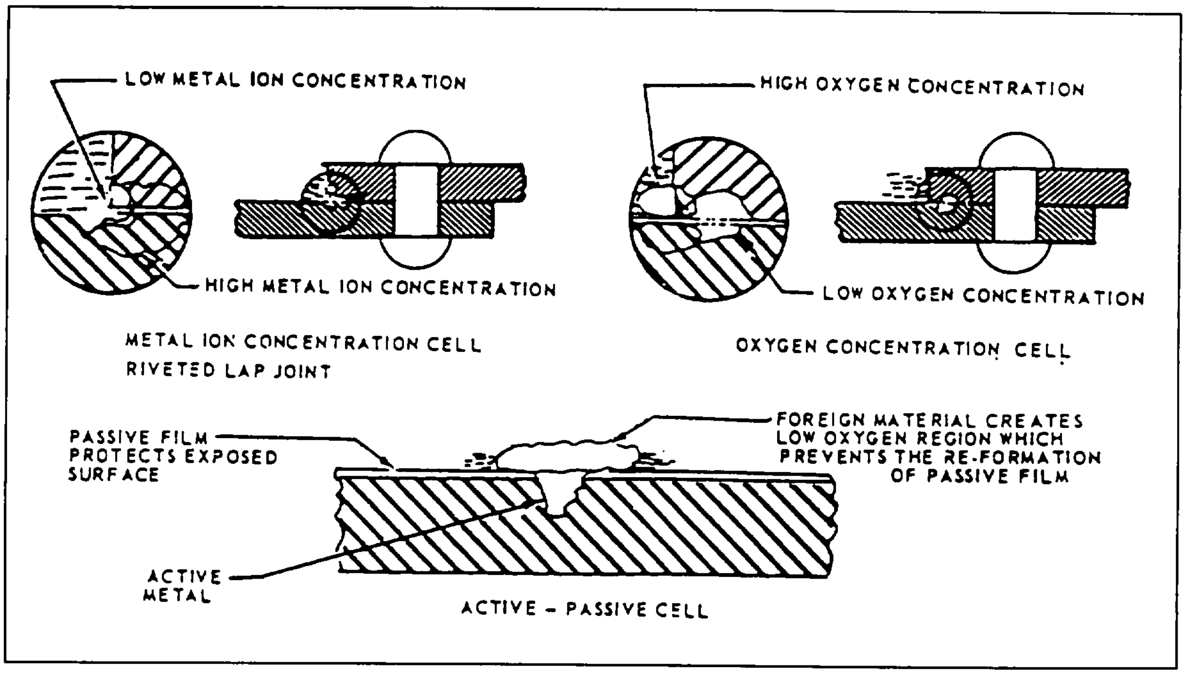


FIGURE 1-22. CONCENTRATION CELL CORROSION

j. Intergranular Corrosion. Intergranular corrosion is an attack along the grain boundaries of a material. Rapid selective corrosion at the grain boundary can occur with subsequent delamination (see Figure 1-23). High-strength aluminum alloys such as 2014 and 7075 are more susceptible to intergranular corrosion if they have been improperly heat-treated and are then exposed to a corrosive environment.

FIGURE 1-23. INTERGRANULAR CRACKING AND CORROSION ON A WINGSPAR CHORD

k. Exfoliation Corrosion. Exfoliation corrosion is an advanced form of intergranular corrosion where the surface grains of a metal are lifted up by the force of expanding corrosion products occurring at the grain boundaries just below the surface. The lifting up or swelling is visible evidence of exfoliation corrosion (see Figure 1-24). Exfoliation is most prone to occur in rolled and wrought products such as extrusions, thick sheet, thin plate, and certain die-forged shapes. This is in contrast with cast products that tend to have a more homogeneous grain structure.

FIGURE 1-24. SEVERE EXFOLIATION CORROSION
(Courtesy of Thomas Flournoy)

13.-199. RESERVED.

CHAPTER 2. VISUAL INSPECTION PROCEDURES

200. GENERAL. Generally, the inspection procedure to be used will be specified by the aircraft or component manufacturers or the FAA in documents such as maintenance or overhaul manuals, AD's, SSID's, or manufacturers' Service Bulletins. If, during maintenance, a condition is found on the aircraft being inspected which may recur on that aircraft or on another of its type, a certified inspector or other appropriate individual should create an inspection procedure covering the condition. Approval of such procedures should be in accordance with appropriate FARs.

201. MATERIAL CONTAINED IN A VISUAL INSPECTION PROCEDURE. Visual inspection procedures should all contain steps in a logical format. A procedure has four basic parts: (1) a basis for the inspection, (2) preparatory arrangements, (3) implementation of the inspection, and (4) evaluation of the results. Table 2-1 is a listing of all the elements to be considered when creating or reviewing an inspection procedure. Each of the items in the Table should be addressed in the procedure if relevant for the specific inspection.

TABLE 2-1. TOPICS TO BE CONSIDERED IN PREPARING OR REVIEWING A VISUAL INSPECTION PROCEDURE

BASIS FOR INSPECTION
Reason for and purpose of the inspection including any relevant background information.
References to controlling documentation, for example: Advisory Circulars, Airworthiness Directives, Manufacturers and general NDT Manuals, Maintenance and other relevant manuals.
Controlling dates: Effective date of the inspection, date before which the inspection should be accomplished, inspection interval, date at which the inspection no longer is necessary.
Effectiveness; aircraft, engine, or part number.
Time and labor required for the inspection.
Conditions under which the inspection is no longer necessary.
PREPARATION
Preparation and cleaning of the item being inspected.
Any special requirements of the inspection such as unusual surface preparation (etching, paint removal) or the temperature range over which the inspection is effective.
Identification of any equipment necessary for the inspection together with provisions for periodic calibration thereof.
Identification of the specific materials approved for the inspection. These may be included in a referenced Qualified Products List.
IMPLEMENTATION
Specific description of the area to be inspected.
Instructions for carrying out the inspection.
Description of the defect to be detected, preferably with an illustration of a sample defect.
Postcleaning instructions if required.
Instructions for disposition of the article if it cannot be returned to service.
EVALUATION
Procedure for establishing inspection reliability.
Accept/reject criteria.
Reporting requirements.

202. ACTIVITIES APPLYING TO ALL VISUAL INSPECTIONS. Some activities which represent good practice may not be specifically called out in the procedures, but should be completed if they are relevant. Examples of such good practice are:

a. Preliminary Inspection. A preliminary inspection of the overall general area should be performed for cleanliness, presence of foreign objects, deformed or missing fasteners, security of parts, corrosion, and damage. If the configuration or location of the part conceals the area to be inspected, it is appropriate to use visual aids such as mirror or borescope.

b. Precleaning. The areas or surface of parts to be inspected should be cleaned without damaging any surface treatment which may be present. Contaminants that might hinder the discovery of existing surface indications should be removed. Some cleaning methods may remove indications of damage; care should be used if the cleaning tends to smear or hide possible indications of trouble. Surface coatings may have to be removed at a later time if other NDI techniques are required to verify any indications that are found. Some typical cleaning materials and methods used to prepare parts for visual inspection are detergent cleaners, alkaline cleaners, vapor degreasing, solvent cleaners, mechanical cleaning, paint removers, steam cleaning, and ultrasonic cleaning.

c. Corrosion Treatment. Any corrosion found in the preliminary inspection should be removed before starting a close visual inspection of any selected part or area. Manufacturers' handbooks, when available, are a good general guide for treatment of corrosion. Recommendations of AC 43-4A, if appropriate, should be used on aircraft for which the manufacturer has not published a recommended corrosion inspection schedule or treatment program. The AC contains a summary of current available data regarding identification and treatment of corrosion on aircraft structure and engine materials. Examples of types of corrosion damage detectable by the visual method are also given.

d. Use of Visual Aids. When inspecting the area required, visual aids should be used as necessary. An inspector normally should have available suitable measuring devices: a flashlight and a mirror. Chapter 3 provides information on lighting techniques that can be used when inspecting for defects in different types of materials.

203. RECORD KEEPING. All defects found should be documented by Maintenance Record entry, written report, squawk sheet, photograph, or video recording for appropriate evaluation. Depending on the rules governing the facility and person performing the inspection, the report may be limited to simply reporting findings without any rejection or acceptance disposition. The type, location, and approximate size of any defects present should be documented. Based upon the particular inspection process specification (i.e., AD, Service Bulletin, Maintenance Manual requirement, or normal inspection discovery) the mechanic, repairman, or other authorized person should determine the particular acceptance, re-

work, repair or rejection status of the part or structure being inspected.

a. Findings. One of the most important elements of the visual inspection process is the nature of the report of findings. As a guide, the record of findings for any defects should be kept in a manner as to permit others who may be doing the same inspection to have the benefit of any previous information found and experience gained.

b. Maintenance of Records. The full value of visual inspection can be realized only if records are kept of the conditions found on parts inspected. The size and shape of the finding and its location should be recorded along with other pertinent information, such as rework performed or disposition. The inclusion of some permanent record of a defect on a report makes the report much more complete.

c. Illustrations as Records. It should be stressed that frequent and effective use of illustrations not only will enhance the effectiveness of the procedure but is indispensable in communicating to the inspector the nature of the defects to be found. In addition to textual and anecdotal data, the following types of records are commonly used:

(1) Sketches. The simplest record is a sketch of the part showing the location and extent of the defect. On large areas it may be sufficient to sketch only the critical area.

(2) Photography. Photographs (still or video recording) of defects can be taken for visual record purposes. Photographs produce a permanent and highly descriptive record since they show both size and location on the part. They are permanent, reproducible, and the required equipment is readily available. It is good practice to include a scale in the photo when practicable as well as some marking for identification. This is particularly necessary if the photograph is likely to become an exhibit involved in litigation.

204. FOUR LEVELS OF VISUAL INSPECTION.

a. Inspection Tasks. Visual inspection tasks are divided into four categories relating to their difficulty and degree of effectiveness as follows:

- Walkaround Inspection.
- General Visual Inspection.
- Detailed Visual Inspection.
- Special Detailed Visual Inspection.

b. Additional Special NDI. An additional category may be used when visual inspection is supplemented by specialized NDI equipment.

205. ACCEPTABLE PRACTICE FOR VISUAL INSPECTION. Acceptable practice for the four levels of visual inspection is defined in the following paragraphs. For each level, the practice is divided into the four parts of the inspection procedure described in Table 2-1. Details of the inspection procedures will vary for different types of operators and aircraft; for example, the walkaround for a general aviation aircraft and a commercial jet will have major differences. It is important however, that the procedure for each aircraft type in a given service be carried out with the same care and detail every time the aircraft is inspected. Also, in all inspections described herein, the inspector should have available and be familiar with the documentation and reporting forms and the ground rules mandating the inspection. Refer to Appendices A through F for sample visual inspection procedures and equipment.

a. Level 1. Walkaround. The walkaround inspection is a general check conducted from ground level to detect discrepancies and to determine general condition and security.

NOTE: This is the only one of the four inspections that may be accomplished by either flight or maintenance personnel. The focus and perspective will vary based on the relation of the inspection to flight or maintenance operations.

(1) Basis for Inspection. Most maintenance instructions mandate walkaround inspections on a periodic basis. The overall purpose is to serve as a quick check to determine if detectable inconsistencies exist which would affect the performance of the aircraft.

(2) Preparation for the Inspection. Aircraft history should be used to gain information useful in inspecting the aircraft (e.g., are there recurring problems or have there been hard landings?). In addition the aircraft should be clean enough for an effective inspection to take place, the necessary tools and equipment should be available (e.g., flashlight, rag, notebook), and other aids, tools, and procedures may be necessary (e.g., inspection of some aircraft is easier if already on jacks, but this is not always necessary).

(3) Implementation. Beginning the inspection at the nose, the inspector should approach the inspection from the perspective of the pilot *and* mechanic by, first, determining general condition and, second, identifying maintenance items. A good rule is to check for items affecting safety, legality, efficiency, and comfort. The following paragraphs give a partial listing of things to look for. Each aircraft will be different, but a surprising number of different aircraft have similar structural details.

- Observe left and right side of fuselage and left and right wings. (Does the aircraft list?) Work to your left. Check general condition of paint. Check exterior surface components within reach. Check windows. Check engine, propellers or fan blades, exhaust area, and pylons. Check leading edges everywhere. Check control surfaces for slop, wear, and security. Check each gear well. Check all entry and exit points to the aircraft. Check static dischargers. Observe surfaces at different angles using available light to enhance surface evaluation.

- Examine according to what the standard condition is. (Question the existence of any unusual condition.) Look for anything different from one side to another. (It is important to shake, push, pull, listen, and feel when possible.) Run your hand over skin junction areas or composite surfaces.

- Walk around twice. (Observations during the first cursory walkaround the aircraft should be used to determine the general condition. On the second time around revisit the areas noted on the initial walk and look for other discrepancies that may be revealed through closer scrutiny of a specific area. This is when specific locations should be observed.)

- Are there major dents or intrusions in the skin? Look for evidence of flexing parts, waves in the skin, weave or bubble in fiber glass or composite components, eroded fairings, and bulging or flattened seals. Are any external components bent? Is there evidence of damage? Check windows for crazing, dirt, and pitting.

- Rivet characteristics should be noted. Observe rivets for damage. Look for loose broken or missing rivets. Localized chipping of paint, cracked paint on sealant, or fretting corrosion are indicative of movement. Look for smoked or stained rivets.

- Check all venting for leaks. Check all input tubing to insure it is clear. Check all antennas for chipping and strikes. Check for obstructions in pitot tubes, static and engine pressure orifices, and temperature venturies.

(4) Findings. Initial findings should be recorded in a personal notebook as soon as discrepancies are discovered. Do not rely on memory. Findings should be transferred to the aircraft log or official record of discrepancy as soon as possible. Recommendations for action will depend on whether the inspection precedes flight operations or maintenance and whether the discrepancy is safety or flight critical.

b. Level 2. General. A general inspection is made of an exterior with selected hatches and openings open or an interior, when called for, to detect damage, failure, or irregularity.

(1) Basis for Inspection. When a specific problem is suspected, the general inspection is carried out to identify, if possible, the difficulty. General inspections are also routinely used when panels are open for normal maintenance.

(2) Preparation for the Inspection. Ensure cleanliness of the aircraft. The necessary tools and equipment required may include flashlight, mirror, notebook, droplight, rolling stool, tools for removal of panels, ladders stands, or platforms. Other aids such as jacking of the aircraft may or may not be discretionary; knowledge of a specific aircraft may be essential; and common problems may require information, even if not on the inspection card.

(3) Implementation. General looking is not enough. As the inspector, you should continually ask "What is wrong with this picture?" Be inquisitive. Question whether you have seen

this before. Move, shake, pull, twist, and push all parts possible. Apply weight to load bearing components. Compare one side to the other if applicable. Be aware of other systems in the inspection area. Look for abnormalities in the area, even if not related to this inspection. Adjusting the source of illumination, view items under inspection from different angles. Is the area pressurized? If so, does this affect any part of the inspection? Inspect all structural components, all moveable parts, all attach points, and brackets. Check all cables, conduits, and hoses for condition and clearance. Check condition and security of load and stress points. Look for chafing and fretting corrosion. Observe proximity of one part to another. Look for loose or missing fasteners, use of proper sealants, noticeable cracks, indications of corrosion, and debris in closed areas. Observe that cables, conduits, and hoses are properly routed. Observe that there is sufficient strain relief. Observe rivets for damage. Look for smoked rivets and discoloration of paint. (Localized chipping of paint, cracked paint on sealant, or fretting corrosion are indicative of movement.)

(4) Findings. Transfer all information relating to discrepancies from your notebook. Record discrepancies as a work order. Discoveries during the inspection may indicate the need for a more detailed inspection. Depending on the findings, this may be either a Level 3 or Level 4.

c. Level 3. Detailed. A detailed visual inspection is an intensive visual examination of a specific area, system, or assembly to detect damage failure or irregularity. Available inspection aids should be used. Surface preparation and elaborate access procedures may be required.

(1) Basis for Inspection. A detailed inspection is called for when a specific problem is suspected and the general inspection dictates additional inspection. Or, if the inspection is otherwise mandated, a detailed visual inspection is carried out to identify, if possible, the difficulty. Detailed inspections are also periodically called for on damage-tolerant aircraft to ensure the airworthiness of the critical structure.

(2) Preparation for the Inspection. Tools and equipment will vary, but may include a prism, supplemental lighting, mirror, magnifying glass, flashlight, dye penetrant, notebook, droplight, rolling stool, and standard and specialized hand tools. Documentation required is specific to the procedures outlined by steps on work cards. Also review the SBs, ADs, aircraft history, and accident reports. Other aids such as knowledge of a specific aircraft and common problems may be essential even if not on the inspection card.

(3) Implementation. The reasoning that originally dictated the inspection should be considered. If it was because

some corrosion was found, then a more in-depth examination is required. If the inspection is in response to an AD for a crack, carefully inspect the surrounding area to rule out additional occurrences or stress induced because of the crack. In a detailed inspection, you are usually searching for failure, damage, or irregularity. Check the condition and security of lockwires and the load and stress points. Look for fretting corrosion. Observe proximity of one part to another. Look for loose or missing fasteners, use of proper sealants, obvious cracks, indications of corrosion, and debris in closed areas. Observe that cables, conduits, and hoses are properly routed. Observe that there is sufficient strain relief. Look to see if any chafing has occurred.

(4) Findings. Recommendations (discoveries during this inspection may indicate the need for a more detailed inspection, such as a Level 4).

d. Level 4. Special Detailed. A special detailed inspection is an intensive examination of a specific item, installation, or assembly to detect damage, failure, or irregularity. It is likely to make use of specialized techniques and equipment. Intricate disassembly and cleaning may be required.

(1) Basis for Inspection. As systems and structures have become more complex, special inspections using extraordinary techniques and equipment have evolved to ensure airworthiness. These are covered in instructions for special detailed inspections. Special detailed inspections are also periodically called for on damage-tolerant aircraft to ensure the airworthiness of the critical structure. This level of inspection may also be invoked based on recommendations from a lower level.

(2) Preparation for the Inspection. Tools and equipment will vary but may include a flashlight, mirror, video borescopes, special aids and tooling, Dremel, rolling stool, image enhancement and recording devices, supplemental lighting, magnifying glass, dye penetrant, notebook, and standard and specialized hand tools. Documentation required is specific to the procedures outlined by steps on work cards; review of SBs, ADs, and aircraft history; and reference to the original or referred discrepancy, if any. Another aid is the discrepancy report from the contracting NDI company.

(3) Implementation. Procedures are defined in detail by the specific instruction procedure, but they are limited to the scope of visual inspection. The locations to be inspected will vary greatly, but may include portions of the aircraft that are inaccessible without major disassembly, such as the interior surface of the wing skin, pylon butt joints, and lap joints. In some of these cases the objective of the inspection may be best

served both practically and economically through the use of NDI techniques.

(4) Findings. Satisfy documentation that specified this level of inspection. Documentation will be both internal and external and may include work cards, ADs and SBs. Recommendations should include recommendations for correction of the discrepancy and follow-up inspection.

206.-299. RESERVED.

CHAPTER 3. VISUAL INSPECTION AIDS

300. GENERAL. The two indispensable aids to visual inspection are illumination and optical aids of various types. Illumination and lighting are crucial to all forms of visual inspection and can vastly affect the inspection outcome. In the following sections these two elements of the inspection process will be discussed. In the lighting section, all the aspects of lighting in the inspection environment are discussed. In the section covering visual aids, most optical devices which have found utility in aircraft inspection are described.

a. Tools. It should be emphasized that eye-mirror-flashlight is an indispensable combination for visual inspection. Aircraft structure and components requiring inspection are frequently located beneath skin, cables, tubing, control rods, pumps, and actuators. Therefore, good secondary access by reflection is often essential. Visual inspection aids usually consist of a strong flashlight, a mirror with a ball joint, and a 2- to 5-power simple magnifier. The mirror should be of adequate size (except for very awkward access situations) with reflecting surface free of dirt, cracks, and worn coating; and the swivel joint should be tight enough to maintain its setting. A magnifying mirror may be useful in some situations. A 10-power magnifier is recommended for positive identification of suspected cracks; however, other NDI techniques, such as dye penetrant, magnetic particle, or eddy current can also be used to verify indications. Visual inspection of some areas can only be accomplished with the use of remote viewing devices, such as borescopes and video imaging systems.

b. Special Techniques. Visual inspection is a ubiquitous process used in many locations and involves numerous special techniques. Each will have an optimum lighting environment and its own types of visual and optical enhancements. It is up to the inspector to select the appropriate illumination and optical aid for the inspection at hand.

301. LIGHTING AND ILLUMINATION. Federal Aviation Regulation, Section 145.35(g) dealing with facilities requires that lighting should be adequate for the work being performed and should not adversely affect the quality of the work. Such lighting can be provided by a combination of general background and supplemental illumination and will vary with practice and be task dependent.

The amount of light needed to perform the variety of seeing tasks in visual inspection of aircraft and related components depends not only on the task itself, but also on the vision and the age of the worker (vision may need correcting with glasses and older eyes require more light), the importance of the task (how critical or expensive is a mistake), and the reflectance of the task background (the greater the difference between task and background, the easier it is to see).

a. General Considerations for Lighting Aircraft Maintenance Areas. The following factors should be considered as all-important requirements of good planning for aircraft maintenance lighting systems:

(1) Safety of Personnel. Determine the quantity, quality, and type of illumination desirable for safety of personnel, the maintenance processes, and the environment.

(2) Selection of Lighting Equipment. Select lighting equipment that will provide the quantity and quality requirements by examining luminance characteristics and performance that will meet installation, operating, and actual maintenance conditions.

(3) Equipment Maintenance. Select and arrange lighting equipment so that it will be easy and practical to maintain.

(4) Energy Management. Energy management considerations and economic factors, including initial operating and maintenance costs versus the quantity and quality requirements for optimum visual performance, should be balanced (reference IES handbooks on lighting, also see Appendix G in this document). Whenever possible, the use of daylight should be considered for maintenance areas. Due consideration should be given to the National Energy Policy Act of 1992 covering the use of energy efficient illumination.

b. Illuminance Values. The IES has provided a range of illuminance values and illuminance categories to be used for generic types of interior activities when specific recommendations are not available (see Table 3-1).

TABLE 3-1. ILLUMINANCE VALUES

ILLUMINANCE CATEGORIES AND ILLUMINANCE VALUES FOR GENERIC TYPES OF ACTIVITIES			
TYPE OF ACTIVITY	ILLUMINANCE CATEGORY	RANGE OF ILLUMINANCES (FOOTCANDLES)	REFERENCE WORK-PLANE
Public spaces with dark surroundings	A	2-3-5	General lighting throughout spaces
Simple orientation for short temporary visits	B	5-7.5-10	
Working spaces where visual tasks are only occasionally performed	C	10-15-20	
Performance of visual tasks of high contrast or small size	D	20-30-50	Illuminance on task
Performance of visual tasks of medium contrast or small size	E	50-75-100	
Performance of visual tasks of low contrast or very small size	F	100-150-200	
Performance of visual tasks of low contrast or very small size over a prolonged period	G	200-300-500	Illumination of task obtained by a combination of general and local (supplementary lighting)
Performance of very prolonged and exacting visual task	H	500-750-1000	
Performance of very special visual tasks of extremely low contrast and small size	I	1000-1500-200	

The IES has also established a procedure (range approach) for selecting illuminance values from the ranges listed in Table 3-1 by using a weighting-factor guidance system, reflecting lighting-performance trends found in research (see Table 3-2). It was established to accommodate a need for flexibility in determining illuminances so that lighting designers could design lighting systems to meet specific needs. Such flexibility requires that additional information be available to effectively use the range approach. To use the range approach, a lighting task should be considered to be composed of the following elements:

TABLE 3-2. WEIGHTING FACTORS TO BE CONSIDERED IN SELECTING SPECIFIC ILLUMINANCE WITHIN RANGES OF VALUES FOR EACH ILLUMINANCE CATEGORY

a. For Illuminance Categories A through C			
Room and Occupant Characteristics	Weighting Factor		
	-1	0	+1
Occupants' ages	Under 40	40-55	Over 55
Room surface reflectances*	Greater than 70 percent	30 to 70 percent	Less than 30 percent
b. For Illuminance Categories D through I			
Task and Worker Characteristics	Weighting Factor		
	-1	0	+1
Workers' ages	Under 40	40-55	Over 55
Speed and/or accuracy**	Not Important	Important	Critical
Reflectance of task background***	Greater than 70 percent	30 to 70 percent	Less than 30 percent

* Average weighted surface reflectances including wall, floor and ceiling reflectances if they encompass a large portion of the task area or visual surroundings. For instance in an aircraft hanger where the ceiling height is 25 feet, neither the task nor the visual surroundings encompass the ceiling, so only the floor and wall reflectances would be considered.

** In determining whether speed and/or accuracy is not important, important, or critical, the following questions need to be answered: What are the time limitations? Will errors produce an unsafe condition or product? Will errors reduce productivity and be costly? For example, in reading for leisure there are no time limitations and it is not important to read rapidly. Errors will not be costly and will not be related to safety. Thus, speed and/or accuracy is not important. If, however, safety notes and process procedures are to be read by NDI personnel, accuracy is critical because errors could produce an unsafe condition, and speed is important for economic reasons.

*** The task background is that portion of the task against which the meaningful visual display is exhibited. For example, on this page the meaningful visual display includes each letter which combines with other letters to form words and phrases. The display medium, or task background, is the paper, which has a reflectance of approximately 85 percent.

(1) Lighting Task Elements.

(i) Visual Display. The visual display is the object being viewed, which is presumed to present some inherent difficulty of observation.

(ii) Observer Age. The age of the observer is a factor in the observer's visual performance.

(iii) Speed and/or Accuracy. The importance of speed and/or accuracy distinguishes between casual, important, and critical seeing requirements.

(iv) Task Reflectance. The reflectance of the task (background against which the details are seen). The reflectance will determine the type of illumination best adapted to the reflectance characteristics of the visual display.

(2) Amount and Type of Light. The above lighting task elements should be considered concurrently to determine the appropriate amount and type of light for the lighting task. Additional information on using this range approach procedure for selecting illuminances is provided by the IES in its handbooks on lighting, and in Appendix G of this document.

c. Industrial Lighting. In addition to generic-activity lighting recommendations, the IES through technical committees and knowledgeable individuals provides lighting recommendations for specific industries. Table 3-3 provides the IES recommended illuminance categories for general industrial inspection area/activity. The IES standards contain lighting recommendations for specific tasks and areas in aircraft maintenance.

TABLE 3-3. IES RECOMMENDED ILLUMINANCE CATEGORIES FOR THE DESIGN AND EVALUATION OF LIGHTING SYSTEMS FOR INDUSTRIAL INSPECTION AREAS

INDUSTRIAL GROUP (*Inspection Area/Activity Only)	
Area/Activity	Illuminance Category**
Inspection	
Simple	D
Moderately Difficult	E
Difficult	F
Very Difficult	G
Exacting	H

* The IES provides a wide variety of industrial area/activity recommendations for illuminance categories in the Industrial Group.

** See Table 3-1.

d. Seeing Tasks. The seeing tasks required for visual inspection of aircraft tend to be three dimensional and curved, rather than two dimensional and flat like seeing tasks found in an office. The seeing task can be almost any distance from the floor, compared with 30 inches for the typical desk top, and in any position from horizontal to vertical. The seeing task can have extremely fine detail requiring thousands of footcandles or be so large that lower levels will suffice. The finish of the article to be inspected (dull or matte versus shiny or mirror-like versus brushed) greatly affects the amount and orientation of the lighting needed for good visibility.

Good visual inspection lighting depends not only on providing the right illumination levels, but also on selecting the proper lamp and luminaire and mounting or positioning it in the right location. In fact, the latter can often have far more effect on task visibility than the lighting level. Figures 3-1, through 3-3 show examples of the effects of article finish and lighting orientation on visibility. The shiny and matte finish micrometers, shown in Figure 3-1, typify a range of seeing tasks and the effect of lighting system orientation. The graduations on the barrel of the matte finish micrometer are highly legible under all three lighting conditions: fluorescent parallel to the barrel (Figure 3-1A), fluorescent perpendicular to the barrel (Figure 3-1B), and high-intensity discharge (HID) downlight (Figure 3-1C).

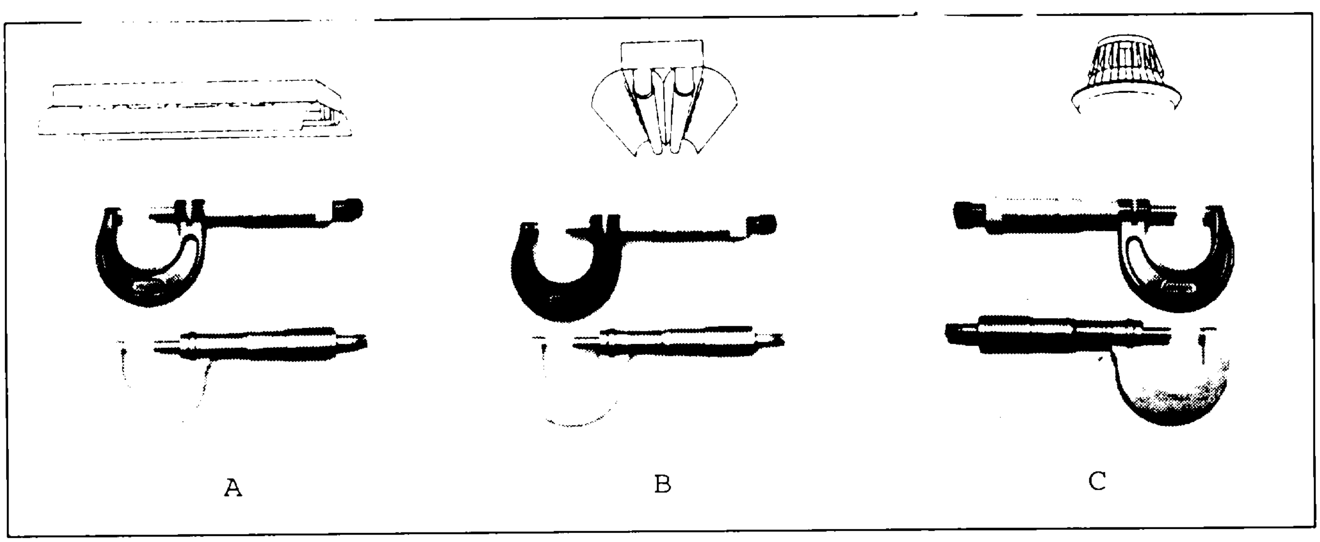


FIGURE 3-1. EXAMPLE OF THE EFFECT OF SHINY AND MATTE FINISH OF PARTS AND LIGHTING SYSTEM ORIENTATION ON SEEING TASKS (Courtesy of General Electric Company)

The graduations of the shiny micrometer cannot be easily read when the barrel is parallel to the fluorescent lighting (Figure 3-1A) because of lines of glare. When the lighting is perpendicular (Figure 3-1B), the reflections wrap around the surface, the contrast is improved substantially, and the graduations are easily legible. The downlight system (Figure 3-1C) tends to be omnidirectional and the legibility of the numbers is intermediate between parallel and perpendicular fluorescent lighting.

The solder connections on the circuit board, shown in Figure 3-2, are difficult to inspect because of the reflections of the bright HID downlight (Figure 3-2A). Under the large, low-brightness fluorescent luminaire (Figure 3-2B), the reflections are soft and diffuse and defects can be easily detected.

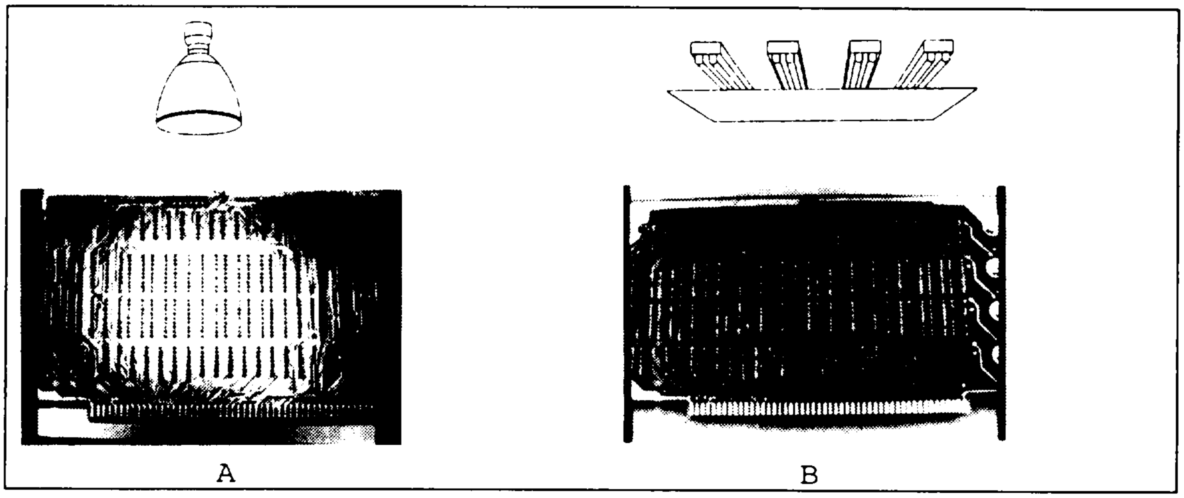


FIGURE 3-2. EXAMPLE OF THE EFFECT OF LIGHTING SYSTEMS ON INSPECTION OF A CIRCUIT BOARD
(Courtesy of General Electric Company)

Scribe marks, shown in Figure 3-3, (and many defects) on polished or lightly etched surfaces are more visible if they are parallel to the fluorescent lighting (Figure 3-3A) rather than at right angles to it (Figure 3-3B), since the surface reflects the darker area between the fixtures and increases the contrast.

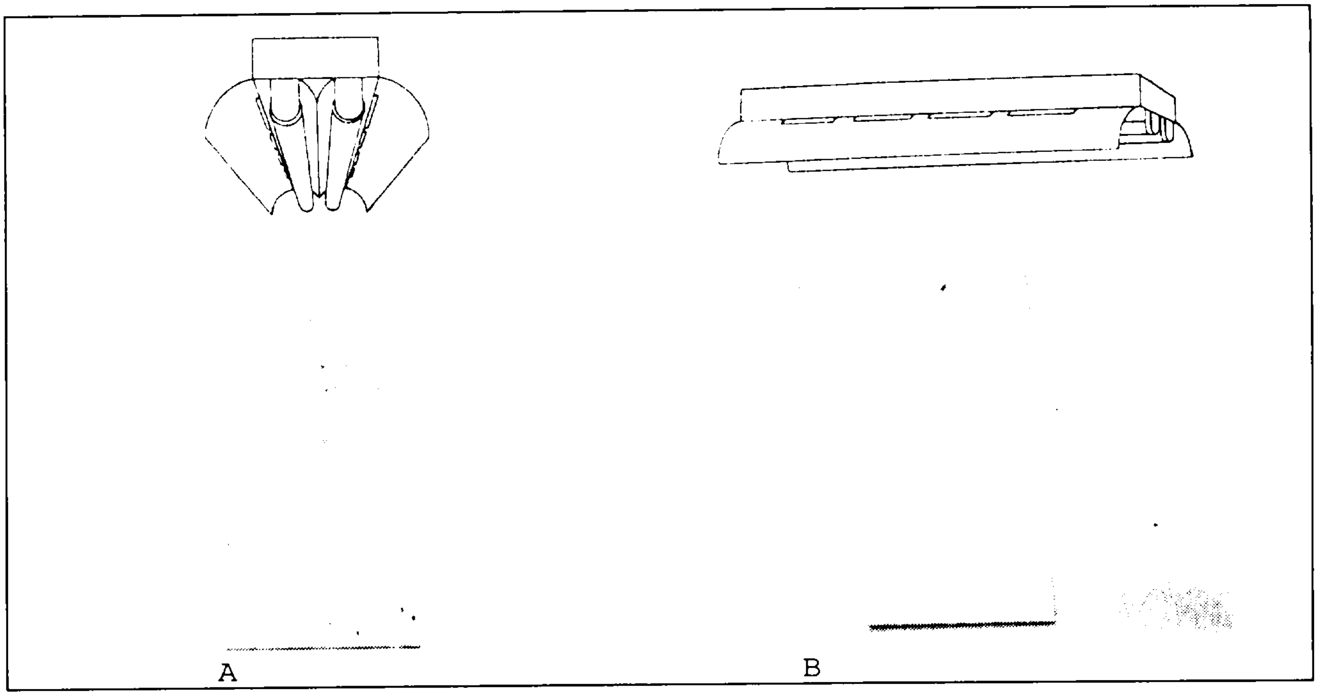


FIGURE 3-3. EXAMPLE OF THE EFFECT OF LIGHTING SYSTEM ORIENTATION ON AN INSPECTION SURFACE (Courtesy of General Electric Company)

e. Classification of Visual Tasks and Lighting Techniques. Visual tasks are unlimited in number, but some can be classified according to certain common characteristics. The detail to be seen in each group can be emphasized by an application of certain lighting fundamentals. Table 3-4 classifies tasks according to their physical and light-controlling characteristics and suggests lighting techniques for good visual perception.

TABLE 3-4. CLASSIFICATION OF VISUAL TASKS AND SUPPLEMENTARY LIGHTING TECHNIQUES (Sheet 1 of 3)

PART I FLAT SURFACES				
CLASSIFICATION OF VISUAL TASK	EXAMPLE		SUPPLEMENTARY LIGHTING TECHNIQUE	
General Characteristics	Description	Lighting Requirements	Luminaire Type*	Locate Luminaire
A. Opaque Materials				
1. Diffuse detail and background				
Unbroken surface	Reading ADs or SBs	High visibility with comfort	S-III or S-II	To prevent direct glare and shadows
Broken surface	Scratch or crack on anodized aluminum	To emphasize surface break	S-I	To direct light obliquely to the surface
2. Mirror finish detail and background				
Unbroken surface	Dent, warps, uneven surface in skin panels	Emphasize unevenness	S-V	So that image of source and pattern is reflected to eye
Broken surface	Scratch, scribe, engraving, punch marks, cracks	Create contrast of cut against mirror finish surface	S-III or S-IV or S-V when not practical to orient task	So detail appears bright against a dark background So that image of source is reflected to eye and break appears dark
Mirror finish coating over mirror finish background	Inspection of finish plating over underplating	To show up uncovered areas	S-IV with color source selected to create maximum color contrast between two coatings	For reflection of source image toward the eye
3. Combined mirror finish and diffuse surfaces				
Mirror finish detail on diffuse, light background	Shiny ink on anodized aluminum	To produce maximum contrast without veiling reflections	S-III or S-IV	So direction of reflected light does not coincide with angle of view
Mirror finish detail on diffuse, dark background	Punch or scribe marks on dull metal	To create bright reflection from detail	S-II or S-III	So direction of reflected light from detail coincide with angle of view
Diffuse detail on mirror finish, light background	Graduation on a steel scale	To create a uniform, low brightness reflection from mirrored background	S-IV or S-III	So direction of reflected light does not coincide with angle of view
Diffuse detail on mirror finish, dark background	Wax marks on aircraft painted surface	To produce high brightness of detail against dark background	S-III or S-II	So direction of reflected light does not coincide with angle of view
B. Translucent Materials				
1. With diffuse surface	Frosted or etched glass or plastic, light weight fabrics	Maximum visibility of surface detail Maximum visibility of detail within material	Treat as opaque, diffuse surface (see A-1) Transilluminate behind material with S-II, S-III, or S-IV	
2. With diffuse surface	Scratch on opal glass or plastic	Maximum visibility of detail within material Maximum visibility of surface detail	Transilluminate behind material with S-II, S-III, or S-IV Treat as opaque, mirror finish surface - See A-2	

TABLE 3-4. CLASSIFICATION OF VISUAL TASKS AND SUPPLEMENTARY LIGHTING TECHNIQUES (Sheet 2 of 3)

CLASSIFICATION OF VISUAL TASK	EXAMPLE		SUPPLEMENTARY LIGHTING TECHNIQUE	
General Characteristics	Description	Lighting Requirements	Luminaire Type*	Locate Luminaire
PART I FLAT SURFACES (Continued)				
C. Transparent Materials				
Clear material with mirror finish surface	Plate glass	To produce visibility of details within material such as bubbles, and details on surface such as scratches	S-V and S-I	Transparent material should move in front of Type S-V, then in front of black background with Type S-I directed obliquely. Type S-I should be directed to prevent glare
D. Transparent over Opaque Materials				
1. Transparent material over a diffuse background	Instrument panel	Maximum visibility of scale and pointer without veiling reflections	S-I	So reflection of source does not coincide with angle of view
	Varnished wing spar	Maximum visibility of detail on or in the transparent coating or on the diffuse background emphasis of uneven surface	S-V	So that image of source and pattern is reflected to the eye
2. Transparent material over a mirror finish background	Glass mirror	Maximum visibility of detail on or in transparent material	S-I	So reflection of source does not coincide with angle of view. Mirror should reflect a black background
		Maximum visibility of detail on mirror finish background	S-V	So that image of source and pattern is reflected to the eye
PART II THREE DIMENSIONAL OBJECTS				
CLASSIFICATION OF VISUAL TASK	EXAMPLE		SUPPLEMENTARY LIGHTING TECHNIQUE	
General Characteristics	Description	Lighting Requirements	Luminaire Type*	Locate Luminaire
A. Opaque Materials				
1. Diffuse detail and background	Dirt on a casting or blow holes in a casting	To emphasize detail with a poor contrast	S-III or S-II or	To prevent direct glare and shadows
			S-I or	In relation to task to emphasize detail by means of highlight and shadow
			S-III or S-II as a black light source when object has a fluorescent coating	To direct ultraviolet radiation to all points to be checked

TABLE 3-4. CLASSIFICATION OF VISUAL TASKS AND SUPPLEMENTARY LIGHTING TECHNIQUES (Sheet 3 of 3)

PART II THREE DIMENSIONAL OBJECTS (Continued)				
CLASSIFICATION OF VISUAL TASK	EXAMPLE		SUPPLEMENTARY LIGHTING TECHNIQUE	
General Characteristics	Description	Lighting Requirements	Luminaire Type*	Locate Luminaire
2. Mirror finish detail and background				
a. Detail on the surface	Dent in polished aluminum skin	To emphasize surface unevenness	S-V	To reflect image of source eye
	Inspection of finish plating over underplating	To show up areas not properly plated	S-IV plus proper color	To reflect image of source to eye
b. Detail in the surface	Scratch or crack on polished aluminum skin	To emphasize surface break	S-IV	To reflect image of source to eye
3. Combination mirror finish and diffuse				
a. Mirror finish detail on diffuse background	Scribe mark on casting	To make line glitter against dull background	S-III or S-II	In relation to task for best visibility. Adjustable equipment often helpful. Overhead to reflect image of source to eye
b. Diffuse detail on mirror finish background	Micrometer scale	To create luminous background against which scale markings can be seen in high contrast	S-IV or S-II	With axis normal of micrometer
B. Translucent Materials				
1. Diffuse surface	Interior lighting diffusers	To show imperfections in material	S-II	Behind or within for transillumination
2. Mirror finish surface	Glass enclosing globe, frosted lens cover	To emphasize surface irregularities	S-V	Overhead to reflect image of source to eye
		To check homogeneity	S-II	Behind or within for transillumination
C. Transparent Materials				
Clear material with mirror finish surface	Windshields	To emphasize surface irregularities	S-I	To be directed obliquely to objects
		To emphasize cracks, chips, and foreign particles	S-IV or S-V	Behind for transillumination. Motion of objects helpful

f. Quality of Illumination. Quality of illumination pertains to the distribution of luminances in the visual environment. The term is used in a positive sense and implies that all luminances contribute favorably to visual performance, visual comfort, ease of seeing, safety, and esthetics for the specific visual task involved. Glare, diffusion, direction, uniformity, color, luminance, and luminance ratios all have a significant effect on visibility and the ability to see easily, accurately, and quickly. Certain industrial seeing tasks, such as visual inspection, require discernment of fine details and need much more careful analysis and higher quality illumination than others.

Whenever possible, the quality of illumination for the particular visual inspection task being performed should be checked, including the use of test parts with discontinuities of the type being sought. Areas where the seeing tasks are severe and performed over long periods of time require much higher quality than where seeing tasks are casual or of relatively short duration. Industrial lighting installations of very poor quality are easily recognized as uncomfortable and are possibly hazardous. Unfortunately, moderate lighting deficiencies are not readily detected, although the cumulative effect of even slightly glaring conditions can result in substantial loss of seeing efficiency and undue fatigue.

(1) Glare, General. Glare is unwanted light in the field of view which causes loss in visual performance and visibility. It occurs when luminances within the visual field are substantially greater than the amount of luminance to which the eyes are adapted. It can be caused by a source of light (direct glare) or can be reflected from any surface in the room including the task (reflected glare).

(2) Direct Glare. Direct glare is often the result of the luminaire not shielding the lamp from view (see Figures 3-4A and 3-4B). It may be noticeably severe with lamps of high luminance values. For example, a clear 250-watt, high-pressure sodium lamp that emits 27,500 lumens from a cigarette-size arc tube will be much brighter than a 400-watt, metal-halide lamp emitting 36,000 lumens from a melon-size, phosphor-coated lamp envelope. Portions of some mirrored reflectors can reflect an overly bright image of the lamp (see Figure 3-4C). Lens-enclosed luminaires may eliminate bare-lamp brightness, but can themselves cause direct glare at certain angles. Fluorescent luminaires, with their relatively low-brightness lamps, usually will be less glaring. Avoiding direct glare is simply a matter of choosing the right luminaire and its location.

(3) Reflected Glare (Veiling Reflection). Reflected glare is somewhat more insidious than direct glare. Images of the lamps or the luminaires are reflected from the viewing task (see Figure 3-4D). These veiling reflections can be severe enough to cause errors during visual inspection. The following suggestions are provided for avoiding reflected glare:

- Change the position of the viewing task and/or the offending luminaire(s), if practicable. This will change the angular relationship between the light source, task, and observer, thereby directing the offending reflection elsewhere.

- Use a dull or matte finish, not a shiny one, on surfaces surrounding the task such as the machinery, tools, benches, walls, etc.

- Replace clear lamps with diffuse-coated ones.

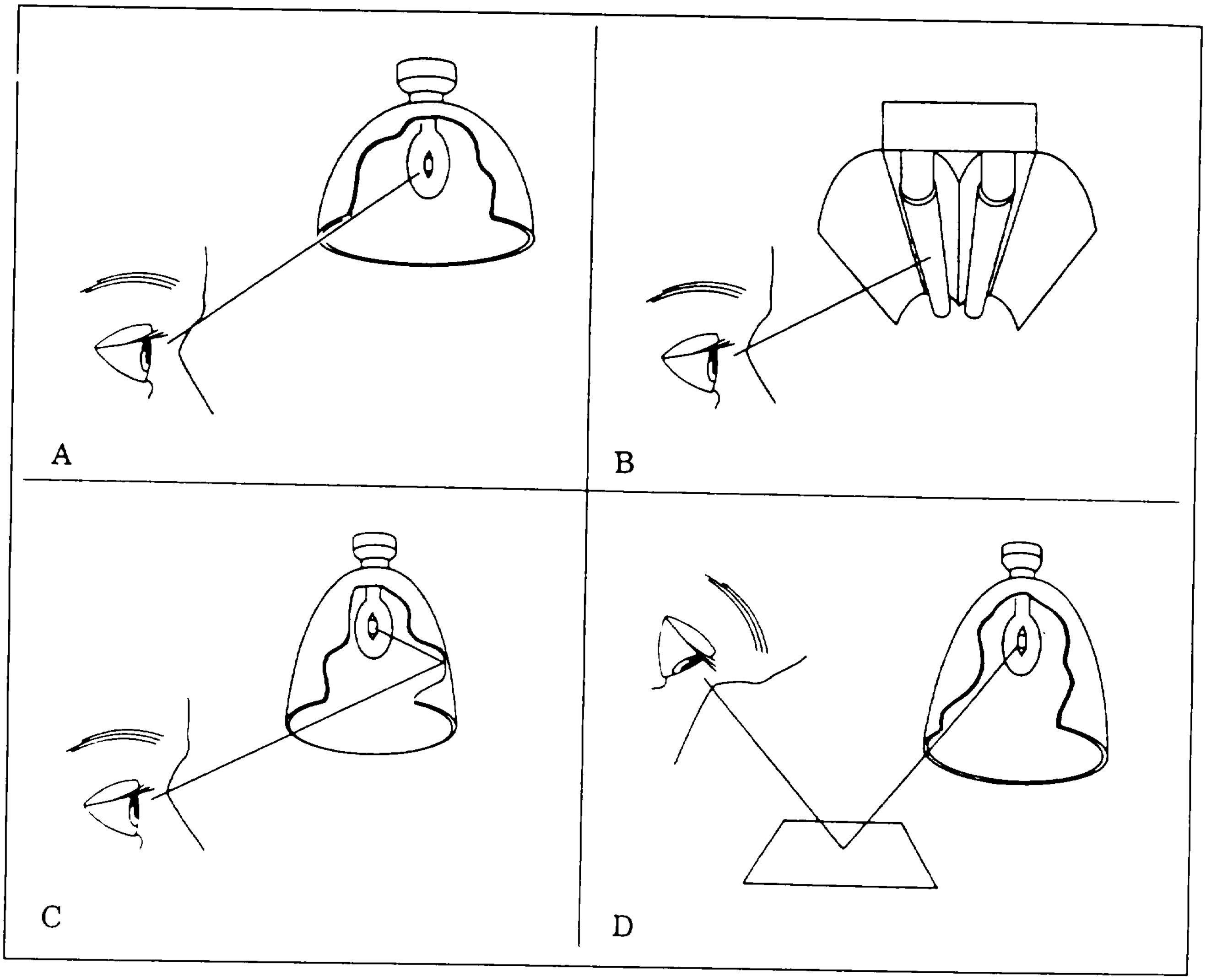


FIGURE 3-4. EXAMPLES OF DIRECT AND REFLECTED GLARE
(Courtesy of General Electric Company)

- Change the lighting system, if required. For example, replace HID downlight luminaires with those that have large-area lenses (large surfaces will be less bright and reduce reflections) or with fluorescent.

- Use a large-area fluorescent lighting system. The reflections will be uniform and low in luminance. A translucent panel system is often recommended for inspecting mirrored metal and plastic articles for surface defects.

- Use specialized supplementary lighting where the glare problem is limited to a few locations.

g. Luminaire Shielding. The purpose of a luminaire is to control or direct the light from the lamp. This is accomplished by the size, shape, and material of the reflector and auxiliary devices such as baffles, louvers, lenses, and diffusers.

For industrial lighting applications, including inspection areas, shielding should be at least 25 degrees and preferably approaching 45 degrees (see Figure 3-5), especially in areas of high illumination levels or with high-brightness lamps. Fluorescent fixtures might also require crosswise baffles or louvers if inspection personnel view the lamps lengthwise. At low mounting heights, well-shielded, narrow-beam luminaires, particularly HID, may produce puddles of light at the viewing task level. If wider beamspread and better uniformity is obtained by reducing shielding, the visible bare lamp becomes glaring. The following recommendations are provided for avoiding this problem:

(1) Low Mounting Heights. Install HID luminaires that have been designed for low mounting heights. These have large diameter reflectors and refractors that provide the widespread beam. Because the light from the lamp is spread over the refractor's much larger areas, it in effect becomes the light source. Therefore, the brightness is diluted and reduced to tolerable levels. Brightness will vary with the lamp's output and the size of the refractor.

(2) Narrow-Beam Luminaires. Use more of the same narrow-beam luminaires, but with lower-wattage lamps and closer spacing. Properly selected, there will be both acceptable overlap and reduced direct glare. Fluorescent lamps, even though they are inherently lower in brightness than HID lamps, should have deep reflectors and lateral baffles.

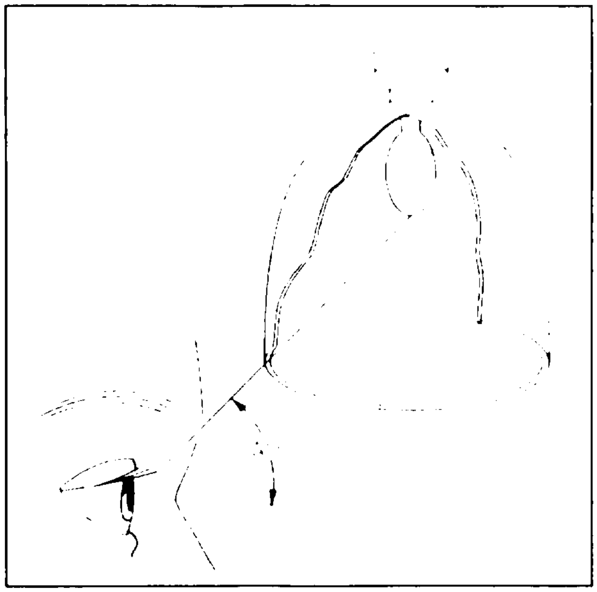


FIGURE 3-5. EXAMPLE OF LUMINAIRE SHIELDING ANGLE
(Courtesy of General Electric Company)

h. Uniformity of Illumination. Uniformity refers to the variations in illumination levels that occur at the work plane, typically with the highest level under the luminaire and the lowest in between luminaires. The IES considers illuminance to be uniform if the maximum level is not more than one-sixth above the average level; or the minimum, one-sixth below. Uniform horizontal illumination is called for in most lighting designs where seeing tasks require the same levels. Closer spaced luminaires improve uniformity and ensure continued illumination in the event one or two luminaires are temporarily extinguished. Using IES recommended reflectances (see Table 3-5) helps improve uniformity and helps reduce unwanted shadows. Ceilings should be painted a flat white to reduce contrast between fixture and ceiling and to increase illumination. The key to satisfactory uniform lighting is to observe the fixture manufacturer's recommended maximum spacing-to-mounting-height ratio or a similar guide, the spacing criterion.

TABLE 3-5. RECOMMENDED REFLECTANCE VALUES FOR INDUSTRIAL LIGHTING

SURFACES	REFLECTANCE* (Percent)
Ceiling	80 to 90
Walls	40 to 60
Desk and bench tops, machines and equipment	25 to 45
Floors	not less than 20

* Reflectance should be maintained as near as practical to recommended values.

(1) Maintaining Uniformity. Maintaining uniformity of illumination between adjacent areas which have significantly different visibility and illumination requirements might be wasteful of energy; for example, a storage area adjacent to a machine shop. In such instances, it is prudent to design and apply non-uniform lighting between those areas. It may be accomplished by using luminaires of different wattage and/or by adjusting the number of luminaires per unit area. Local lighting restricted to a small work area is unsatisfactory unless there is sufficient general illumination.

(2) Harsh Shadows. Harsh shadows should be avoided, but some shadow effect may be desirable to accentuate the depth and form of objects. There are a few specific visual tasks where clearly defined shadows improve visibility and such effects should be provided by supplementary lighting equipment arranged for the particular task. Figures 3-6 and 3-7 illustrate how shadows can aid or hinder the seeing of details. In the case of curved and faceted surfaces which are polished or semipolished, the direction of the lighting is important in controlling highlights. Some shadow contributes to the identification of form.

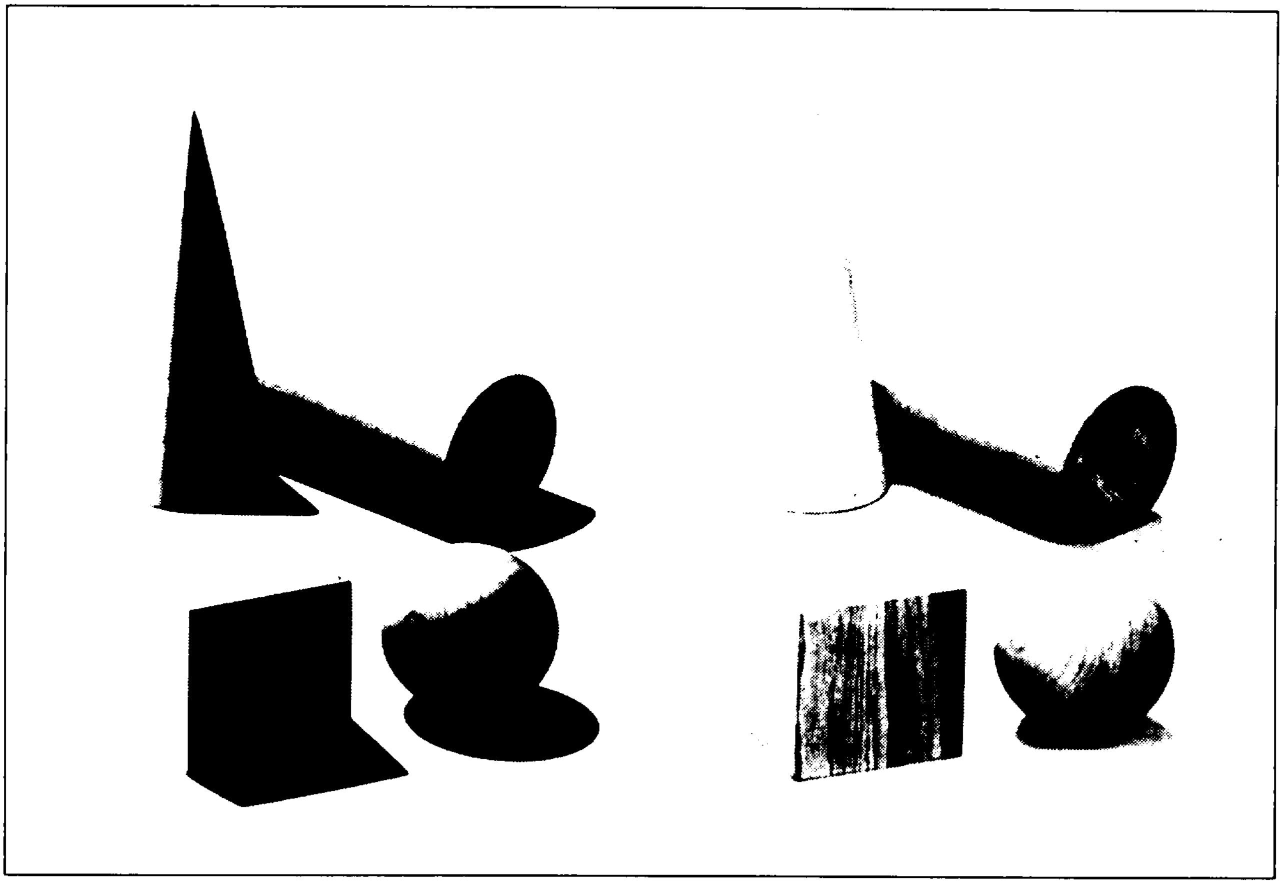


FIGURE 3-6. HARSH SHADOWS PRODUCED BY UNIDIRECTIONAL ILLUMINATION (Left) AND SOFT SHADOWS PRODUCED BY DIFFUSE ILLUMINATION

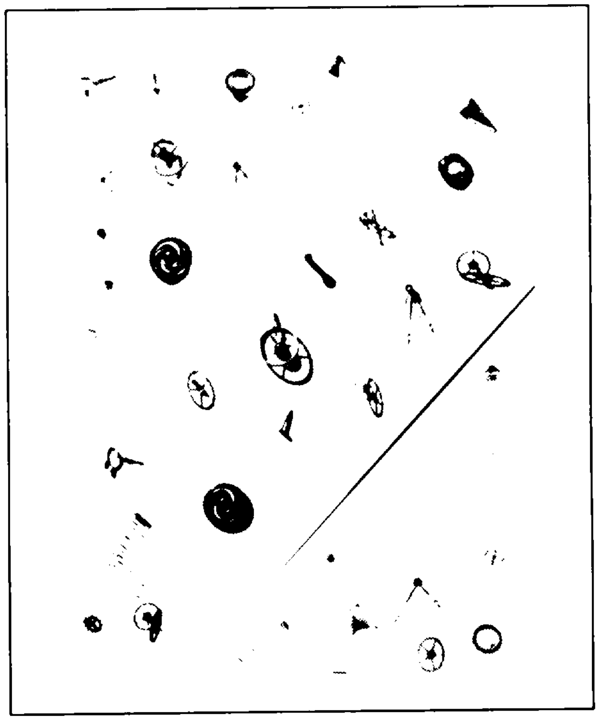


FIGURE 3-7. MULTIPLE SHADOWS (Upper Left) ARE CONFUSING; SINGLE SHADOWS (Center) MAY CONFUSE, BUT CAN HELP; DIFFUSED LIGHT (Lower Right) ERASES THE SHADOWS

(3) Brightness. Brightness is the strength of sensation which results from viewing surfaces or spaces from which light comes to the eye. This sensation is determined in part by luminance (which can be measured) and in part by conditions of observation, such as the state of adaptation of the eye. The eye responds to differences in brightness or contrast. Improving the contrast of the seeing task is the goal of the lighting designer. However, extreme variations in brightness in the surrounding field of view can make seeing more difficult or even uncomfortable. The eye becomes tired when the pupil has to adjust constantly from light to dark and back again. As recommended by the IES, the ratio of the luminance of the seeing task to the surrounding areas for comfortable seeing is shown in Table 3-6.

TABLE 3-6. RECOMMENDED MAXIMUM LUMINANCE RATIOS FOR INDUSTRIAL LIGHTING

	Environmental Classification*		
	A	B	C
1. Between tasks and adjacent darker surroundings	3 to 1	3 to 1	5 to 1
2. Between tasks and adjacent lighter surroundings	1 to 3	1 to 3	1 to 5
3. Between tasks and more remote, darker surfaces	10 to 1	20 to 1	+
4. Between tasks and more remote, lighter surfaces	1 to 10	1 to 20	+
5. Between luminaires (windows, skylights, etc.) and surfaces adjacent to them	20 to 1	+	+
6. Anywhere within normal field of view	40 to 1	+	+

* Classifications are:

A Interior areas where reflectances of entire space can be controlled in line with recommendations for optimum seeing conditions.

B Areas where reflectances of immediate work area can be controlled, but control of remote surroundings is limited.

C Areas (indoor and outdoor) where it is completely impractical to control reflectances and difficult to alter environmental conditions.

\+ Luminance ratio control not practical.

i. <u>Color</u>. Accurate color identification is required for many visual inspection tasks of aircraft and related articles (color-coded electronic wiring and tubing, paint, penetrant and magnetic particle inspection indications, corrosion, safety signs, etc.). The inspectors' reaction to various colors and how they feel about the area can also be important. Most characteristics of a light source can be analyzed objectively; however, color and color-rendering properties are much more subjective. Additional information on color is provided by the IES in its handbooks on lighting.

(1) <u>Chromaticity</u>. Chromaticity or color temperature (whiteness) of a light source sets the tone of the space: warm (yellow, pink) or cool (blue, green). It is measured in Kelvins (K). The warmer the appearance, the lower the number; the higher the number, the bluer or cooler the color. Figure 3-8 shows the approximate color temperatures in Kelvins of several electric light sources and daylight.

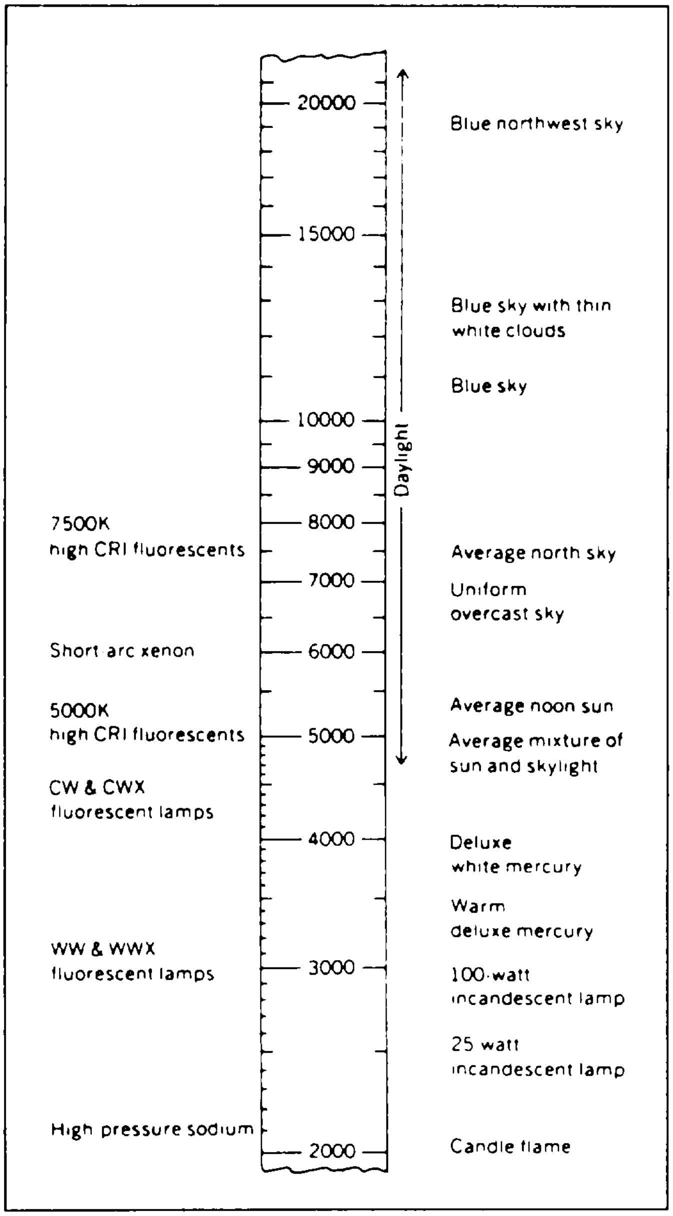


FIGURE 3-8. CORRELATED COLOR TEMPERATURE IN KELVINS OF SEVERAL ELECTRIC LIGHT AND DAYLIGHT SOURCES

(2) Color-Rendering. Another important quality of a light source is its ability to render the color of objects in a natural or familiar way. This is usually expressed in terms of a color-rendering index, or how well a lamp compares with a reference source of the same color temperature. The higher the number, the more nearly like the reference source. Fluorescent lamps are available in a wide range of color temperatures and color-rendering capabilities. When good color-rendering is extremely critical for inspection operations, daylight-simulating lamps are recommended. High-intensity discharge lamps trade-off,

color-rendering for high efficiency and render colors in the good to poor range, however, metal halide lamps are the preferred HID source where color-rendering is important. Additional information on light source color-rendering is provided by the IES in its handbooks on lighting and in technical literature available from manufacturers of light sources.

(3) Illuminance Levels. The lighting recommendations in Table 3-1 and Table 3-4 provide a guide for efficient visual performance rather than for safety alone; therefore, they are not to be interpreted as requirements for regulatory minimum illuminance levels.

j. Types of Lighting Equipment. The manner in which light is controlled by the lighting equipment governs to a large extent the important effects of glare, shadows, distribution, and diffusion. Luminaires are classified in accordance with the way in which they control the light. Figure 3-9 gives the standard International Commission on Illumination (CIE) classifications for interior lighting equipment.

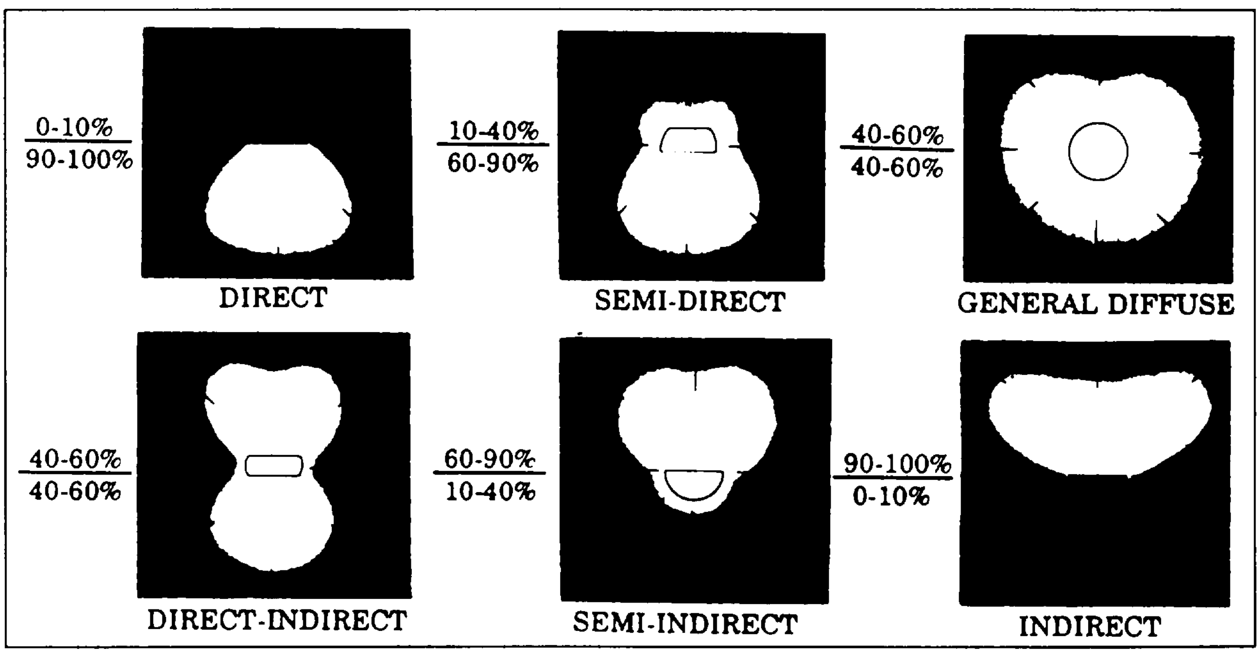


FIGURE 3-9. INTERNATIONAL COMMISSION ON ILLUMINATION LUMINAIRE CLASSIFICATIONS FOR GENERAL LIGHTING

(1) Lighting Applications. Most aircraft maintenance lighting applications call for either direct or semi-direct types of illumination. Industrial luminaires for fluorescent, high-intensity discharge and incandescent filament lamps are available with upward light components which contribute to visual comfort by balance of luminances between luminaires and their back-

grounds. Figure 3-10 shows some typical lamp and fixture light distribution curves. Luminaires also require adequate shielding for visual comfort (see Figure 3-5). The shielding angle is particularly important for higher luminance sources. Good environmental luminance relationships can also often be achieved with totally direct lighting if the illuminances and room surface reflectances are high.

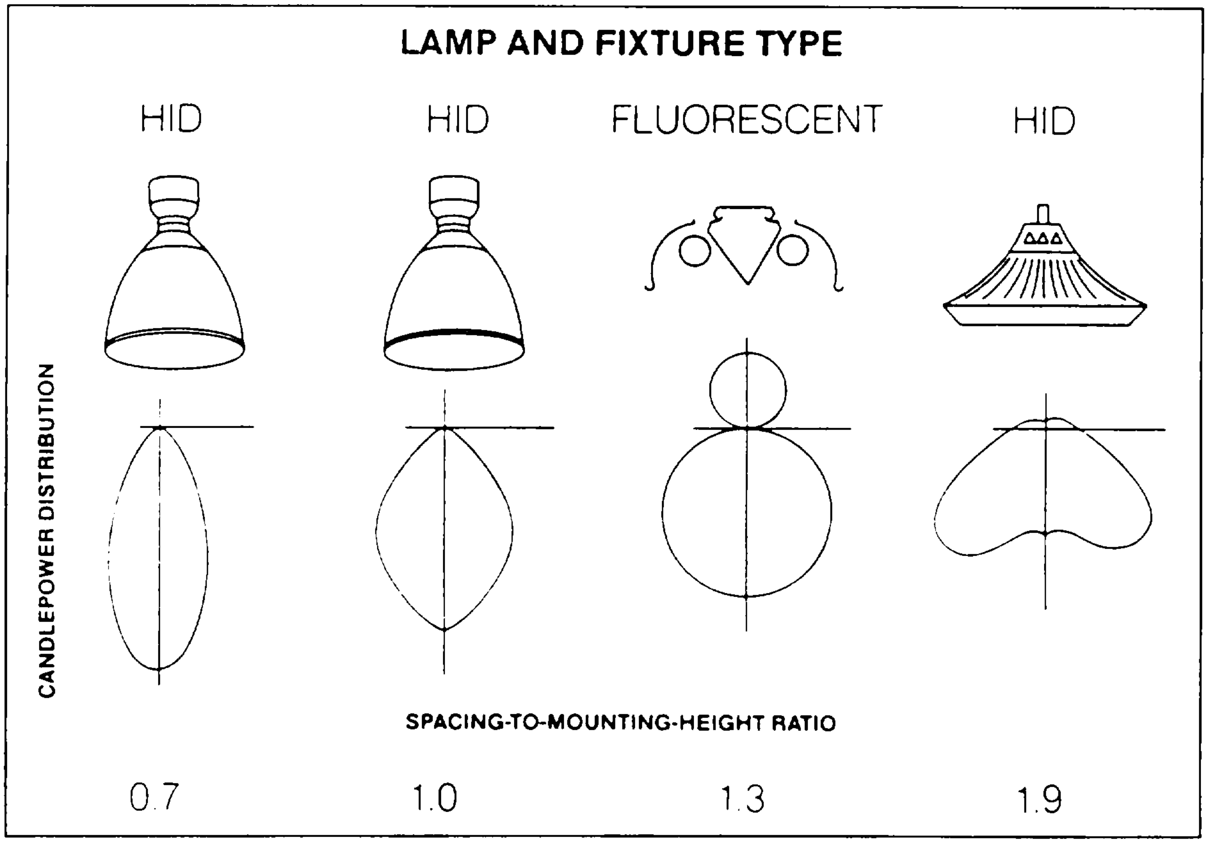


FIGURE 3-10. TYPICAL LAMP AND FIXTURE LIGHT DISTRIBUTION CURVES (Courtesy of General Electric Company)

Luminaires with upward components of light are preferred for most areas because an illuminated ceiling or upper structure reduces luminance ratios between luminaires and the background. The upward light reduces the dungeon effect of totally direct lighting and creates a more comfortable and more cheerful environment as shown in Figure 3-11. It shows the importance of a white ceiling in an industrial facility under construction. Note the improved visual environment in the right bay (where the painters have finished the ceiling) compared with that in the left bay (as yet, unpainted). The illuminance in the right bay is also substantially higher.

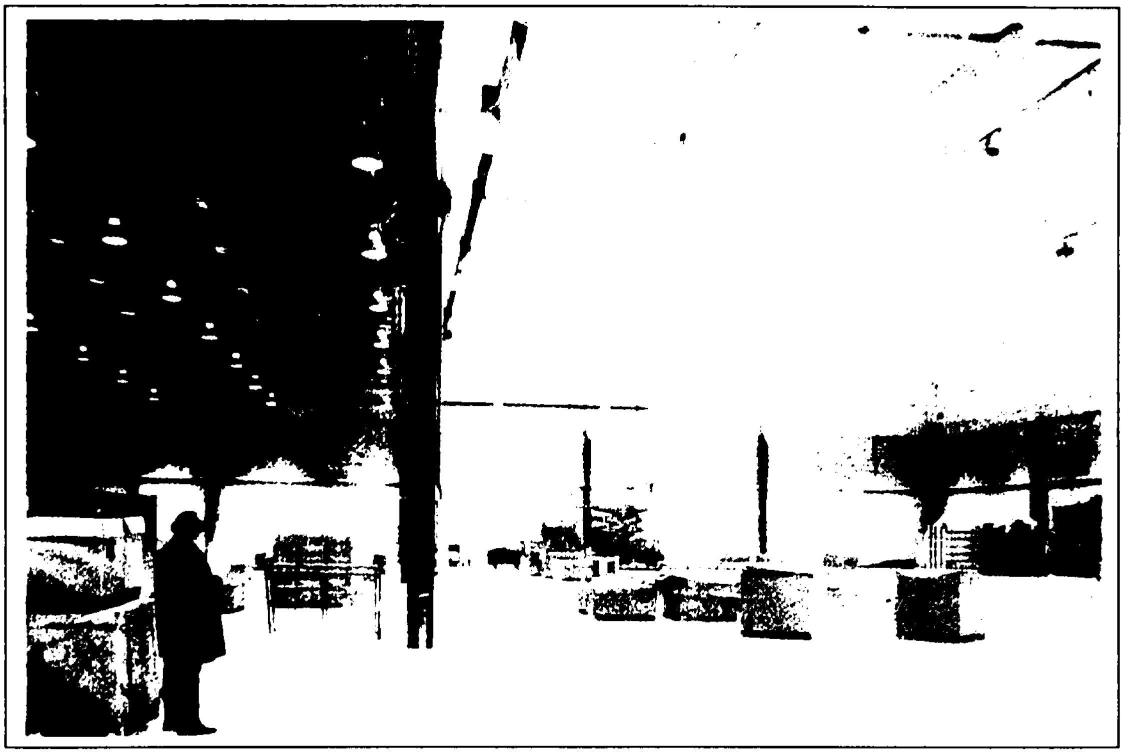


FIGURE 3-11. ILLUSTRATION OF THE IMPORTANCE OF A WHITE CEILING FOR IMPROVING THE VISUAL ENVIRONMENT OF AN INDUSTRIAL FACILITY
(Courtesy of General Electric Company)

(2) Luminaire Top Openings. Top openings in luminaires generally minimize dirt collection on the reflector and lamp by allowing an air draft path to move dirt particles upward and through the luminaire to the outer air. Therefore, ventilated types of luminaires have proven their ability to minimize maintenance of fluorescent, high-intensity discharge, and incandescent filament types of luminaires. Gasketed dust-tight luminaires are also effective in preventing dirt collection on reflector and lamp surfaces.

(3) High Humidity or Corrosive Atmosphere and Classified (Hazardous) Location Lighting. The National Fire Protection Association (NFPA) is phasing out the word "Hazardous" for the word "Classified."

- Nonclassified Areas. Enclosed gasketed luminaires are used in nonclassified areas where atmospheres contain nonflammable dusts and vapors or excessive dust. Enclosures protect the interior of the luminaire from conditions prevailing in the area. Severe corrosive conditions necessitate knowledge of the atmospheric content to permit selection of proper material for the luminaire.

- Classified Areas. Classified locations are areas where atmospheres contain inflammable dusts, vapors, or gases in explosive concentrations. They are grouped by the National Electrical Code on the basis of their hazardous characteristics, and all electrical equipment should be approved for use in specific classes and groups. Luminaires are available, specifically designed to operate in these areas, which are noted in Article 500 of the National Electrical Code as Class I, Class II, and Class III locations. Luminaires used in these areas are designated as: explosion-proof, dust-tight, dust-proof, and enclosed and gasketed.

(4) Other Factors. In selecting industrial lighting equipment, the following other factors lead to more comfortable lighting installations:

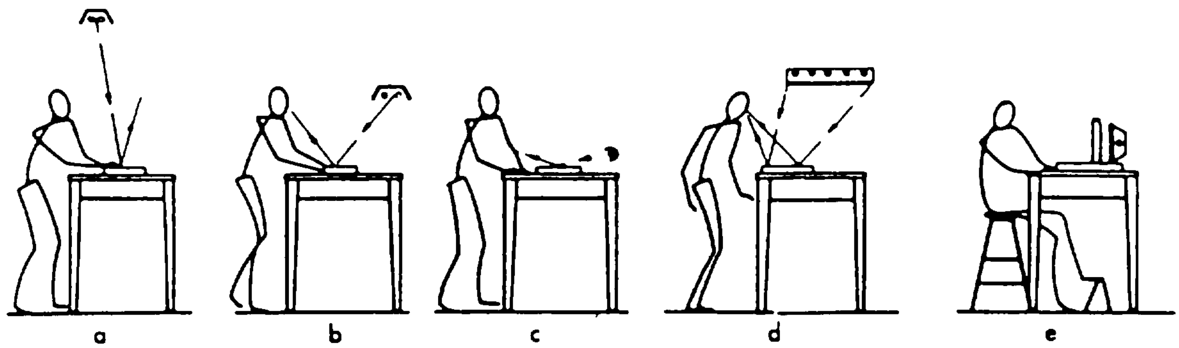
- Light-colored finishes on the outside of luminaires to reduce luminance ratios between the outside of the luminaire and the inner reflecting surface and light source.

- Higher mounting heights to raise luminaires out of the normal field of view.

- Better shielding of the light source by deeper reflectors, cross baffles, or louvers. This is particularly important with high-wattage incandescent filament or high-intensity discharge sources and the higher output fluorescent lamps.

- Selecting light control material, such as mirrored or nonmirrored aluminum, prismatic configured glass, or plastic that can limit the luminaire luminance in the shielded zone.

k. Supplementary Lighting. Difficult seeing tasks often require a specific amount or quality of lighting which cannot readily be obtained by general lighting methods. Supplementary luminaires are often used to solve such problems by providing higher illuminances for small or restricted areas. Supplementary luminaires are also used to furnish a certain luminance, color, or to permit special aiming or positioning of light sources to produce or avoid highlights or shadows to best portray the details of the task. Figure 3-12 shows examples of placement of supplementary luminaires.



Examples of placement of supplementary luminaires: a. Luminaire located to prevent veiling reflections and reflected glare; reflected light does not coincide with angle of view. b. Reflected light coincides with angle of view. c. Low-angle lighting to emphasize surface irregularities. d. Large-area surface source and pattern are reflected toward the eye. e. Transillumination from diffuse source.

FIGURE 3-12. EXAMPLES OF PLACEMENT OF SUPPLEMENTARY LUMINAIRES

(1) Nature of Visual Task. Before supplementary lighting can be specified, it is necessary to recognize the exact nature of the visual task and to understand its light reflecting or transmitting characteristics. An improvement in the visibility of the task will depend upon one or more of the four fundamental visibility factors: luminance, contrast, size, and time. Therefore, in analyzing a visual task, it may be found that seeing difficulty is caused by insufficient luminance, poor contrast (veiling reflections), small size, or that the task motion is too fast for existing seeing conditions.

(2) Planning of Supplementary Lighting. The planning of supplementary lighting also entails consideration of the visual comfort of both those workers who benefit directly and those who are in the immediate area. Supplementary equipment should be carefully shielded to prevent glare for the users and their associates. Luminance ratios should be carefully controlled. Ratios between task and immediate surroundings should be limited as recommended in Table 3-5. To attain these limits it is necessary to coordinate the placement of supplementary and general lighting.

(3) Luminaires for Supplementary Lighting. The IES divides supplementary lighting units into five major types according to candlepower distribution and luminance as follows:

- Type S-I-Directional: Includes all concentrating units. Examples are a reflector spot lamp or units employing concentrating reflectors or lenses. Also included in the group are concentrating longitudinal units, such as a well-shielded fluorescent lamp in a concentrating reflector.

- Type S-II-Spread, High Luminance: Includes small-area sources, such as incandescent or high-intensity discharge. An open-bottom, deep-bowl diffusing reflector with a high-intensity discharge lamp is an example of this type.

- Type S-III-Spread, Moderate Luminance: Includes all fluorescent units having a variation in luminance greater than two-to-one.

- Type S-IV, Uniform Luminance: Includes all units having less than two-to-one variation of luminance. Usually this luminance is less than 640 candelas per square foot. An example of this type is an arrangement of lamps behind a diffusing panel.

- Type S-V, Uniform Luminance With Pattern: A luminaire similar to Type S-IV, except that a pattern of stripes or lines is superimposed.

l. Portable Luminaires. Whenever possible, supplementary luminaires should be permanently mounted in the location to produce the best lighting effect. Adjustable arms and swivels will often adapt the luminaires to required flexibility. Portable equipment (see Table 3-7), however, can be used to good advantage where it should be moved in and around movable machines or objects, such as in airplanes, or where internal surfaces should be viewed. The luminaires should be mechanically and electrically rugged to withstand possible rough handling. Lamps should be guarded and of the rough-service type. Guards or other means should protect the user from excessive heat. Precautions should be taken to prevent electrical shock. Cords should be rugged and insulation should conform to environmental requirements.

TABLE 3-7. TYPICAL PORTABLE LUMINAIRES FOR SUPPLEMENTARY LIGHTING (Sheet 1 of 7)
(Courtesy of McMaster-Carr Supply Company)

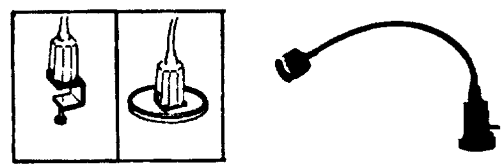
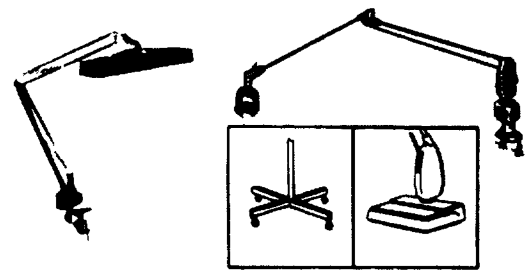
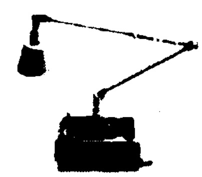
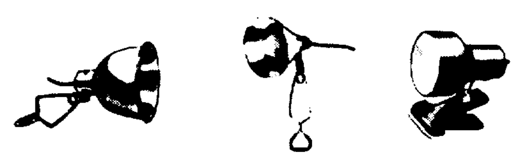
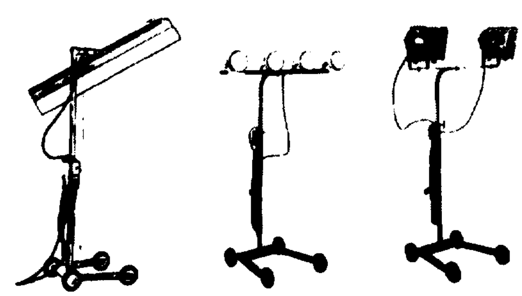
ADJUSTABLE ARM LIGHTS	
a. Gooseneck Lights. These lights have an adjustable gooseneck and are available with high-intensity or standard incandescent lamps. They are also available with magnetic base, table base, C-clamp mount, and explosion-proof housings. They operate on 120V AC.	
b. Floating Arm Lights. These lights are available with high-intensity fluorescent or standard incandescent lamps and have a floating arm that is adjustable by lightly touching with a finger. They are also available with magnetic base, caster base, weighted base, table base, universal mount, and waterproof or explosion-proof housings. They operate on 120V AC.	
c. Adjustable High-Intensity Lights. This has a five-position switch that provides varying light intensities. The arm has an 18-inch reach and swivels 360° horizontally and vertically, eliminating wire twist. It operates on 120V AC.	
d. Clip-On Lights. These lights are available with high intensity or standard incandescent lamps and have a spring-loaded clip to attach practically anywhere. Lights have an adjustable shade to allow directing of light beam. They operate on 120V AC.	
PORTABLE UTILITY LIGHTS	
a. Caddy-Mounted and Tripod-Base Lights. Caddy-mounted and tripod-base lights are available with standard incandescent, fluorescent and high-intensity lamps. They operate on 120V AC.	

TABLE 3-7. TYPICAL PORTABLE LUMINAIRES FOR SUPPLEMENTARY LIGHTING (Sheet 2 of 7)
(Courtesy of McMaster-Carr Supply Company)

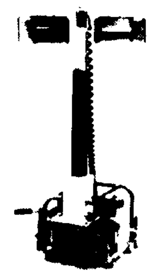
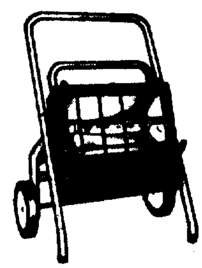
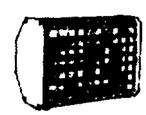
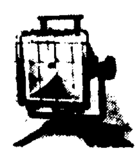
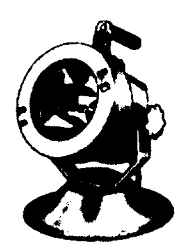
PORTABLE UTILITY LIGHTS (Continued)	
b. Self-Powered Flood Lights. Self-powered lights are available with gasoline or diesel engines and metal malide or high-pressure sodium lamps. They have a telescoping base that is adjusted with a winch and two semi-pneumatic tires. They are available with 120- and/or 240-V AC outlets.	
c. High Pressure Sodium Light Cart. The light cart produces high-intensity lighting with a wide-angle beam. The light has a tempered glass lens with a wire guard and the cart has two 10-inch wheels and a heavy-gauge steel frame with a handle for easy portability. The cart operates on 120V AC.	
d. Polygon Quartz Halogen Floodlights. A polygon-shaped frame can be positioned on any of five sides to aim the light beam where it is needed. A halogen lamp is suspended between springs for maximum impact and vibration resistance. It operates on 120V AC and is UL listed for wet locations inside and outdoors.	
e. High-Intensity Floodlights. These lights have up to 500 watts of high-intensity illumination in rugged easy to carry units with fixed or bolted-down swivel base. They operate on 120V AC.	 
f. Explosive-Proof Floodlight. This floodlight has a cast aluminum housing with a heat and impact-resistant glass lens. The light moves 135° vertically in a yoke and the base swivels 360° and can be bolted down, It uses incandescent medium-base spot or flood lamps and also accepts reflector spot or flood lamps. It operates on a maximum of 600V AC and it is UL standard 844 listed Class I Groups C and D for 150-watt lamps and Class I, Group B for 300-watt lamps.	

TABLE 3-7. TYPICAL PORTABLE LUMINAIRES FOR SUPPLEMENTARY LIGHTING (Sheet 3 of 7)
(Courtesy of McMaster-Carr Supply Company)

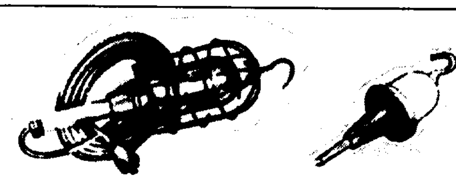
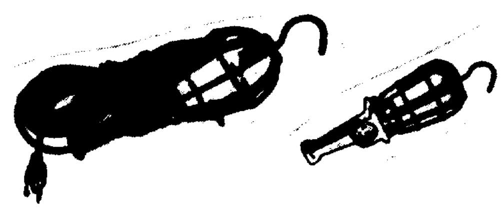
PORTABLE UTILITY LIGHTS (Continued)	
g. Corrosion-Resistant Floodlights. This Floodlight is suitable for use in damp, corrosive conditions. The fixture has a protective wire guard, a locking base, and a plastic carrying handle. It operates on 120V AC and UL listed.	
INCANDESCENT TROUBLE LIGHTS	
a. General-Purpose Trouble Light. These general purpose heavy duty lights use 100-watt incandescent lamps. They operate on 120V AC, meet OSHA specifications and are UL listed.	
b. Vapor-Proof Trouble Lights. These lights are available with a tempered glass or plastic globe that screws into the handle to form a vapor-proof seal. They use a 100-watt lamp and operate on 120V AC. They are UL listed for enclosed and gasketed fixtures and meet OSHA and National Electrical Code (NEC) requirements.	
c. Flood and Spot Trouble Light. This light uses a flood or spot lamp and has a welded metal guard. This trouble light operates on 120V AC, meets OSHA specifications, is UL listed and CSA approved.	
d. Magnetic Base Trouble Lights. These trouble lights can be hung by a swivel hook or attached to a ferrous surface with a magnet built into the handle base. They operate on 120V AC, use a 75-watt bulb and are UL listed.	
e. Hazardous Location Trouble Light. This trouble light is spark and weather resistant with an aluminum guard and swivel hook. It operates on 120 volts AC. It is UL listed for Standard A21 incandescent lamps up to 100 watts and Class II, Group G using a 75-watt A21 lamp.	
f. Coiled Cord Trouble Light. This trouble light has a coiled cord that resists kinks and knots. The 75-watt light operated on 125V AC. meets OSHA specifications for general use and is UL listed.	

TABLE 3-7. TYPICAL PORTABLE LUMINAIRES FOR SUPPLEMENTARY LIGHTING (Sheet 4 of 7)
(Courtesy of McMaster-Carr Supply Company)

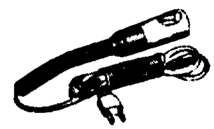
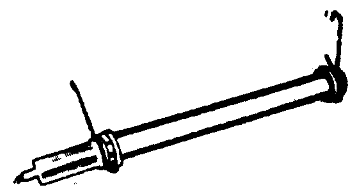
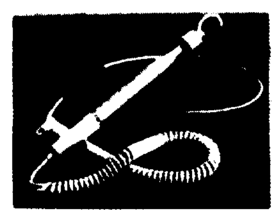
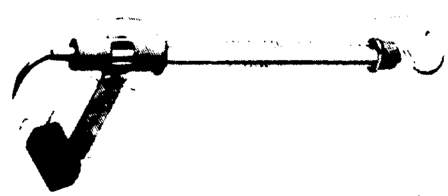
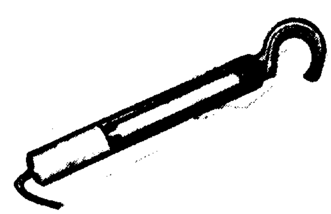
INCANDESCENT TROUBLE LIGHTS (Continued)	
g. Trim-Line Nonconductive Trouble Light. This light is completely insulated and won't spark. The light has a flexible, oilproof rubber handle and a tubular nylon guard. The light uses a 7C7 7-watt incandescent lamp and operates on 120V AC.	
FLUORESCENT TROUBLE LIGHTS	
a. Watertight Trouble Lights. These lights have a butyrate shield and neoprene rubber end cap and handle seal to keep out water and dampness. They have hinged hooks on the end cap and handle that allow them to be easily positioned in the work area. They are available with 20-watt or 40-watt T-12 fluorescent lamps, operate on 120-V AC and are FM approved.	
b. Coiled Cord Trouble Light. This small light slips into hard-to-reach, hard-to-light places. It has a coiled tangle resistant cord that extends up to 13 feet. A butyrate shield protects the lamp from direct contact. It is available with 6-watt and 8-watt T-5 fluorescent lamps. It operates on 120V AC and is FM approved.	
c. Magnetic Base trouble Light. This fluorescent light can be stuck to ferrous surfaces and has an arm and adjustable bracket for quick secure positioning. It has an 8-watt lamp protected by a shatterproof plastic tube. It operates on 120V AC and is UL listed.	
d. Compact Trouble Light. The 4-watt model has no exposed metal beyond the ballast; 8-watt model has a grounded metal reflector. It is available with a magnetic holder. Lights come with an 18-foot SJ cord and plug. The diameter is 1 5/16 inches and the length is from 10 inches (4 watt) to 15 inches (8 watt). It operates on 120V AC.	

TABLE 3-7. TYPICAL PORTABLE LUMINAIRES FOR SUPPLEMENTARY LIGHTING (Sheet 5 of 7)
(Courtesy of McMaster-Carr Supply Company)

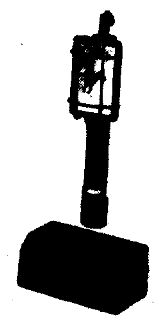
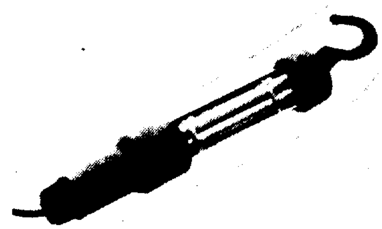
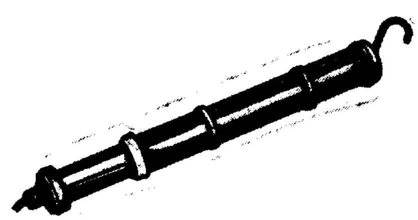
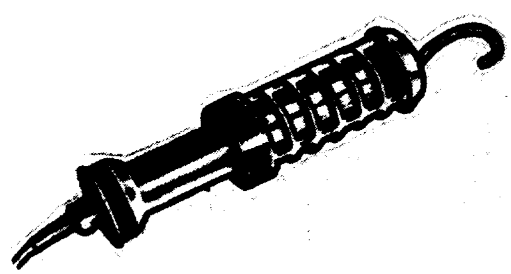
FLUORESCENT TROUBLE LIGHTS (Continued)	
e. Cordless Rechargeable Trouble Light. This light provides the convenience of going anywhere without the hassle of an electrical cord. The light operates for about two hours before needing a recharge and can be recharged in three hours. It had a 6-watt 3.6 halogen lamp, protected by a stainless steel wire guard. The body is made of durable antishock plastic. Overall length is about 14 inches. Lights come with three 1.2V rechargeable nickel cadmium batteries with a rated life of 8 years. It is available for use with 120V AC or 12V DC and comes with a battery charger. It is UL listed.	
f. Compact Twin-Tube Trouble Light. The light has a 13-watt double tube fluorescent lamp to provide twice the illumination of other lights of the same size. It has a rubber handle and end cap and impact resistant plastic tube shield with built-in reflector. The overall size is 14 inches long by 2 9/16 inch diameter. It operates on 120V AC and is UL listed and CSA certified.	
g. Hazardous Location All-Purpose Trouble Light. This light has a non-sparking all aluminum body with annealed glass lamp shield and built-in reflector. The lamp is protected by shock absorbers and an aluminum guard. The light is 27 inches long by 3 1/4 inch diameter with a 15-watt T-8 lamp. It meets National Electrical Code Class I, Div. 1 and 2, Group D; Class II, Div. 1 and 2, Groups E, F, and G; Class III, Div. 1 and 2. The cord, ballast, and lamp unit are FM approved.	
h. Hazardous Location Compact Twin-Tube Trouble Light. The light has bumper guards and end caps to protect against damage from falling objects, bumping, and dropping. The annealed glass globe is protected by an aluminum guard. It is 14 3/4 inches long by 3 1/2 inch diameter and comes with a 16/3 SO cord and 13-watt lamp. It operates on 120V AC, is FM approved, and meets National Electrical Code Class I, Div. 1, Groups C and D; Class II, Div. 1, Groups E, F, and G; and Class III, Div. 1.	

TABLE 3-7. TYPICAL PORTABLE LUMINAIRES FOR SUPPLEMENTARY LIGHTING (Sheet 6 of 7)
(Courtesy of McMaster-Carr Supply Company)

FIBBER-OPTIC ILLUMINATORS
a. Quartz Halogen Fiber-Optic Illuminator. The illuminator is used to produce a high-intensity lighc beam from the tip of fibber optic bundles to light hard-to-reach places. The light is cold after it passes through a fiber-optic light guide, which keeps heat away from the point of inspection. The illuminator is equipped with a basic 0.625 inch opening with reducer bushings provided for adaptability to various other lights guides. It has a variable intensity control with preset divisions to allow for repetitive presettings. The unit operates on 110-V, 60-Hertz AC, 2 amps. The lamp is 150 watt, 3350° Kelvin, 21V. Fiber-optic guides and accessories are normally ordered separately.
b. Xenon Fiber-Optic Illuminator. This illuminator is twice the brightness of the above quartz halogen unit. It is meant for applications where an ultra-high intensity light source is necessary such as long borescopes that use fiber-optic illumination or for illuminating light absorbing materials. The unit operates on 110V, 50/60-hertz AC, 6.2 amps. The lamp is a 300 watt, 6000° Kelvin, 35 to 50V DC. Fiber-optic accessories are normally ordered separately.
FIBBER-OPTIC LIGHT GUIDES
a. Flexible Light Guides. These light guides are made to be used with fiber-optic illuminators. These light guides are flexible and will not support themselves. They are generally used in applications where the light guide has to be fastened to a part that is movable or they are used with a light guide stand.
b. Light Guide Stand. A light guide stand allows a flexible fiber-optic light to be positioned where it is needed and also has an adjustable lens that projects a clear circle of light that can be adjusted from a large area to an intense spot. The stand has 6 1/4-inch vertical travel and 2-inch horizontal travel at the base, and 5 1/2-inch travel at the lens barrel. It also features 360° vertical and horizontal rotation.
c. Free-Standing Light Guides. These light guides are made to be used with fiber-optic illuminators and are adjustable at any angle to the workpiece. They can be used as secondary lighting to built-in illumination systems where the primary light source is insufficient due to long working distances or light absorbing workpieces. They are available in single or double styles.
ILLUMINATION ACCESSORIES
a. Ring Illuminators. Ring illuminators are made to be used with fiber-optic illuminators. They provide a circle of light over 360° leaving no shadow pockets, which is not possible with other illumination systems. The ring illuminator can be used as the prime light source for measuring microscopes, monocular, or sterno-viewing microscopes. or as a secondary light source for profile projectors, 35-mm cameras or closed-circuit TV systems.
b. Micro-Probe Illumination. These illumination systems are used with fiber-optic illuminators and are used in illuminating ultra-small holes and cavities that pose special viewing problems. Available probe diameter are 0.032 and 0.120 inch.

TABLE 3-7. TYPICAL PORTABLE LUMINAIRES FOR SUPPLEMENTARY LIGHTING (Sheet 7 of 7)
(Courtesy of McMaster-Carr Supply Company)

ILLUMINATION ACCESSORIES (Continued)
c. Co-Axial Illuminator. A co-axial illuminator is used with fiber-optic illuminators. It can illuminate the workpiece 10 to 12 inches and further from the lens system. It is used where the workpiece needs illumination where a deep cavity is involved that the present ring illuminators or separate fiber-optic bundles cannot illuminate properly as they are off the optical axis. The unit is used for machine vision video applications, optical comparators as well as microscope usage provided that there is sufficient microscope working distances.
d. Back Light Illumination System. The illuminator is used with fiber-optic illuminators. It illuminates an area of 3 square inches and can be switched from bright field to dark field by a simple control knob on the side of the unit. It can be used as an inspection tool for electronics where dark field illumination is desired and it can be used as background illumination for various microscopes and video applications.

m. Flashlights. Flashlights used for aircraft inspection should be suitable for industrial use and, where applicable, safety approved by the Underwriters Laboratory or equivalent agency as suitable for use in hazardous atmospheres. Military Specification MIL-F-3747E, Flashlights: Plastic Case, Tubular (Regular, Explosion-Proof, Explosion-Proof Heat Resistant, Traffic Directing, and Inspection-Light) provides requirements for flashlights suitable for use in aircraft inspection. However, at the present time, the flashlights covered by this specification use standard incandescent lamps, and there are no standardized performance tests for flashlights with the brighter bulbs (Krypton, Halogen and Xenon). Each flashlight manufacturer currently develops its own tests and provides information on its products in its advertising literature. Therefore, when selecting a flashlight for use in visual inspection, it is sometimes difficult to directly compare products. The following characteristics should be considered when selecting a flashlight: foot-candle rating, explosive atmosphere rating, beam spread (adjustable, spot, or flood), efficiency (battery usage rate), brightness after extended use, rechargeable or standard batteries, if rechargeable, how many hours of continuous use and how long for recharging. If possible, it would be best to take it apart and inspect for quality of construction and to use the flashlight as it would be used in the field. Inspection flashlights are available in several different bulb brightness levels: a. Standard incandescent for long battery life; b. Krypton for 70 percent more light than standard bulbs; c. Halogen for up to 100 percent more light than standard bulbs; and d. Xenon for over 100 percent more light than standard bulbs. Table 3-8 shows some of the typical types of inspection lights that are available.

TABLE 3-8. TYPICAL INSPECTION FLASHLIGHTS (Sheet 1 of 5)
(Courtesy of McMaster-Carr Supply Company)

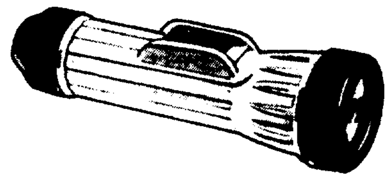
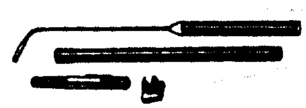
a. Ribbed-Grip Flashlight. This flashlight has a ribbed-grip and a high-impact thermoplastic body that resists oil, grease, chemicals, corrosion. and shock. It is available with standard filament bulbs or Krypton bulbs. It is explosion-proof only with the standard bulb and uses 2 or 3 D-cell batteries. Underwriter laboratories (UL) listed Class I Groups C and D (hazardous vapors and gasses), and Class II Group G, Mine Safety and Health Association (MSHA) approved. The three D-cell model meets American Society for Testing and Materials (ASTM) F1014-86 Type III.	
b. Explosive Atmosphere Flashlight. This flashlight is suitable for use in an explosive atmosphere and has a high-impact ABS resin body. It uses Xenon bulbs and 3 or 4 C-cell batteries. The three cell model has a pocket clip, hanging ring, and wrist lanyard. The four cell model features a backup safety switch and adjustable beam for spot to flood. Factory Mutual (FM) and Mine Safety and Health Association (MSHA) approved, Class I Groups A, B, C, and D. Canadian Standards Association (CSA) certified.	
c. Explosive Atmosphere Penlight. This flashlight has a polycarbonate resin body and pocket clip. It is FM approved. Class I Groups A, B, C, and D. Class II Group G. Class III Div. 1 and 2. CSA certified.	
d. Flexible Light Tool Kit. This light tool kit includes: penlight with extension mirror 1/8-inch-diameter by 10-inch flexible shaft six-inch handle and recovery magnet.	

TABLE 3-8. TYPICAL INSPECTION FLASHLIGHTS (Sheet 2 of 5)
(Courtesy of McMaster-Carr Supply Company)

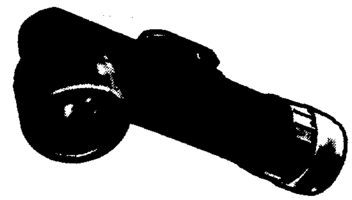
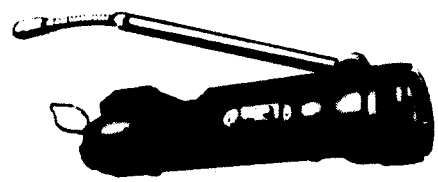
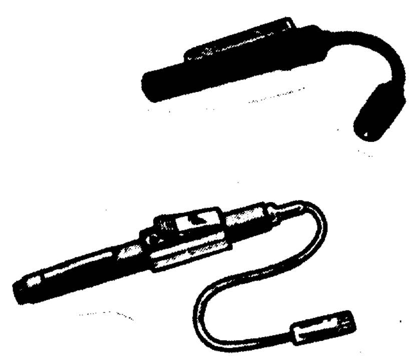
e. Right Angle Explosive Atmosphere Flashlight. A two D-cell model with standard bulb has a waterproof ABS plastic body and three-position switch. It is UL listed, Class I Groups C, and D, and MSHA approved. A rechargeable model with halogen bulb has a waterproof high impact nylon housing with o-ring seals. It is FM approved for use in hazardous locations.	
f. Flexible Krypton Inspection Light. This light contains a krypton bulb that produces a 10,000-candlepower beam. The lamp diameter is 3/16 inch. The flashlight is made of a brass alloy and has a 15-inch-long flexible shaft that bends and keeps its shape. It uses three AA batteries.	
g. Flexible Probe Flashlight. This flashlight stores a 10-inch-long metal probe in the body which snaps out for inspecting tight areas. The body is plastic and has a metal hanging ring. It uses two D batteries and a number PR-2 (standard) bulb.	
h. Pocket Flex Inspection Lights. These lights can be clipped to a nearby spot leaving both hands free while work is accomplished. Flexible cables bend and hold their shape. Cases are plastic. • A mini-flex light has a head that fits through 13/16-inch-diameter openings. Length is 9.8 inches. It uses two AA batteries and a MB22NE (standard) bulb. • An extra power flex light fits through 7/8-inch-diameter openings. Length is 7.5 inches. It uses three AA batteries and M838G3E bulb. An extra reach flex light has a 5/8-inch-diameter bulb. Flexible cable is 8 inches long. It uses two AAA batteries and a E30111 bulb.	

TABLE 3-8. TYPICAL INSPECTION FLASHLIGHTS (Sheet 3 of 5)
(Courtesy of McMaster-Carr Supply Company)

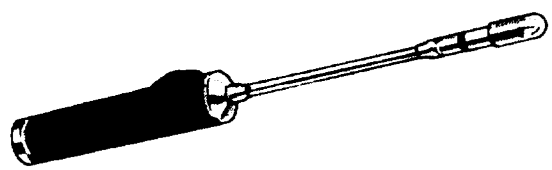
i. Skinny Probe Inspection Light. This light has 44-inch-long flexible cable and the lamp head can pass through a 7/32-inch-diameter opening. The long cable lets you lower the bulb into deep areas and put the flashlight case in your pocket while working. The 3/16-inch-diameter bulb is mounted on the end of a rigid 10-inch-long stem. The unit is impact resistant, waterproof and withstands most chemicals. It uses three D batteries and a number 187 (standard) bulb.	
j. Explosion-Proof Inspection Light. This explosion-proof flashlight has a 14-inch rigid brass or flexible stem that lets you examine fuel tanks and other flammable liquid containers. It uses three D batteries and a number 13 (standard) bulb.	
k. Porta-Power Flex Lights. These inspection lights have a black anodized aluminum case with sliding on-off switch. They focus with a twist of the lens head for pinout or broad beam illumination and they are powered by two D batteries; the lamp head fits through a 21/32-inch opening; they use a number 14 (standard) bulb; and they are available with flexible cable lengths of 9, 18, and 36 inches. A combination unit is available that has a 6-inch rigid shaft and a 9-inch flexible cable.	
l. Inspection Light Accessories. Adjustable illuminating mirrors and magnifiers are available for some model inspection lights. The glass mirror is 1 1/4 inch diameter, has a stainless steel back and nickel plated brass extension arm. Overall length is 4 inches. The illuminating magnifier has a straight line viewing 6X lens. It is 1 1/2 inch diameter with a polished optical glass lens.	

TABLE 3-8. TYPICAL INSPECTION FLASHLIGHTS (Sheet 4 of 5)
(Courtesy of McMaster-Carr Supply Company)

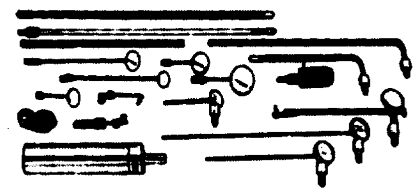
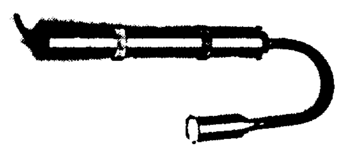
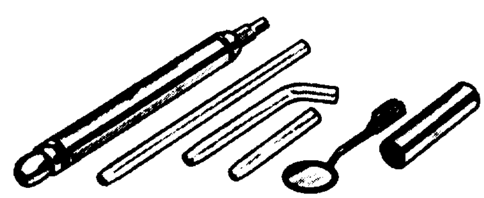
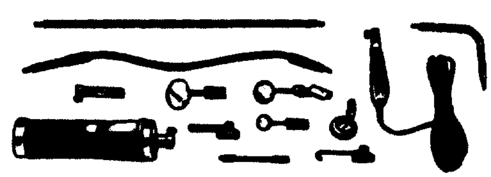
m. Illuminating and Magnifying Inspection Kit. All parts of this kit are interchangeable, interlocking and chrome plated. It uses two D batteries and a 1/8-inch and 1/4-inch-diameter bulb. The kit includes 0.1 inch and 0.3 inch diameter rigid probes in lengths from 3 to 14 1/4 inches, a 0.3-inch-diameter by 14 1/4-inch-long flexible probe, an 8X illuminated magnifier; a 10X duplex magnifier, and adjustable mirror for use on the rigid probes, 0.9 and 1.5-inch-diameter short stem mirrors; recovery magnet and hook; and accessory handle.	
n. Mini Bench Lights. These lights are made to use at the workbench. Lamps can enter a 21/32-inch opening. Each light has a nonsparking aluminum case with a flexible cable (6, 9, or 12 inches long) that bends and stays in position. The electric bench light comes with a 2.5-volt transformer and switch for 110-volt AC outlet. The 5/8-inch-diameter head has a focusing ring for a circle of light or pinpoint beam. The case is shockproof and it uses a number 13 (standard) bulb. The battery operated bench light uses two AA batteries and a number 222 (standard) bulb.	
o. Light Bender Inspection Kit. This kit uses a penlight with a Lucite rod and mirror to see around corners. It uses one or two AA batteries. The kit includes: one and two cell penlight; 6 and 2 1/2-inch-long straight Lucite rods; clip-on mirror; 4-inch curved Lucite rod; and soft plastic case.	
p. Extended Reach Inspection Kit. This kit has up to five-foot reach interchangeable probes, each with its own attached light. The kit includes; a five-foot flexible cable probe; a 12-inch straight and flexible probe; a five-inch angle probe and two-inch bendable probe; a 1.2-inch and 0.6-inch diameter mirror; a 22-mm-diameter mirror; magnifying lens; recovery magnet and hook; shrouded and side aperture lamps; probe adapter; and case.	

TABLE 3-8. TYPICAL INSPECTION FLASHLIGHTS (Sheet 5 of 5)
(Courtesy of McMaster-Carr Supply Company)

q. Twist-Beam Penlights. These flashlights use standard two AA-cell batteries and the beam adjusts from spot to flood.	

302. LIGHTING SYSTEMS. Lighting systems are often classified in accordance with their layout or location with respect to the visual task or object lighted (general lighting, localized general lighting, local [supplementary] lighting, and task-ambient lighting). They are also classified in accordance with the CIE type of luminaire used (direct, semi-direct, general diffuse [direct-indirect], semi-indirect, and indirect), as shown in Figure 3-9. Luminaires for general lighting are classified by the CIE in accordance with the percentages of total luminaire output emitted above and below horizontal. The light distribution curves may take many forms within the limits of upward and downward distribution, depending on the type of light source and the design of the luminaire. Light distribution curves for some typical lamp and fixture types that might be used for visual inspection tasks of aircraft and related articles are shown in Figure 3-10. Light distribution curves may be available in technical literature available from manufacturers of light sources. Horizontal tasks and high, narrow spaces can be most efficiently lighted with fixtures that concentrate most of their light straight down. Such fixtures usually appear to be quite comfortable. However, tasks that are more vertical require light coming from the luminaire at relatively high angles. Luminaires emitting light at high angles are apt to be excessively bright and uncomfortable unless carefully designed. Broad-distribution luminaires are more effective in letting light out of the unit than narrow-distribution ones, but are less effective in getting light to the horizontal work plane in high-bay, narrow spaces since walls absorb a greater portion of the light. Manufacturers generally provide a coefficient of utilization table, which is the ratio between the amount of light or lumens reaching the horizontal task to the lumens generated within the luminaire. The manufacturer's recommended spacing-to-height ratio (or spacing criterion) indicates whether the output of the fixture is broad or narrow.

a. General Lighting. General lighting systems provide an approximately uniform illuminance on the work plane over the entire work area. The luminaires are usually arranged in a symmetrical plan fitted into the physical characteristics of the area and therefore blend well with the room architecture. They are relatively simple to install and require no coordination with furniture or machinery that may not be in place at the time of installation. Perhaps the greatest advantage of general lighting systems is that they permit complete flexibility in task location.

b. Localized General Lighting. A localized general lighting system consists of a functional arrangement of luminaires with respect to the visual task or work areas. It also provides illumination for the entire room area. Such a lighting system requires special coordination in installation and careful consideration to ensure adequate general lighting for the room. This system has the advantages of better use of the light on the work area and the opportunity to locate the luminaires so that annoying shadows, direct glare, and veiling reflections are prevented or minimized.

c. Local Lighting. A local lighting system provides lighting only over a relatively small area occupied by the task and its immediate surroundings. The illumination may be from luminaires mounted near the task or from remote spotlights. These are an economical means of providing higher illuminances over a small area, and it usually permits some adjustment of the lighting to suit the requirements of the individual. Improper adjustments may, however, cause annoying glare for nearby workers. Local lighting by itself is seldom desirable. To prevent excessive changes in adaptation, local lighting should be used in conjunction with general lighting that is at least 20 to 30 percent of the local lighting level; it then becomes supplementary lighting.

d. Task-Ambient Lighting. Task-ambient lighting is a type of lighting arrangement where the lighting is built into the furniture in an open plan office layout. Task lights are located close to work areas (as in local lighting above) and are supplemented by indirect ambient illumination from sources concealed in the furniture and directed to the ceiling (as in general lighting above). These systems usually have extensive ceiling areas almost totally devoid of lighting equipment. Electrical service to the lighting equipment is often through the floor.

e. Direct Lighting. When luminaires direct 90 to 100 percent of their output downward, they form a direct lighting system. The distribution may vary from widespread to highly concentrated, depending on the reflector material, finish, and contour and on the shielding or control media employed.

(1) Direct Glare Control. Direct lighting units can have the highest room utilization factor of all types, but this utilization may be reduced in varying degrees by brightness control media required to minimize direct glare. Direct glare may also be reduced by using area units with minimum number of lamps, e.g., a two-foot-wide fluorescent unit with just two lamps.

(2) Veiling Reflections. Veiling reflections may be excessive unless distribution of light is designed to reduce the effect.

(3) Reflected Glare and Shadows. Reflected glare and shadows may be problems unless close spacings are employed. Large area units are also advantageous in this respect. High-reflectance room surfaces are particularly important with direct lighting to improve the brightness relationships, and higher illuminances provided by controlled brightness equipment will also tend to improve the brightness relationships throughout the room. With very concentrated distributions, care should be taken to ensure adequate wall luminances and illuminances on vertical surfaces.

(4) Other Forms of Direct Lighting. Luminous ceilings, louvered ceilings, and large-area modular lighting elements are forms of direct lighting having characteristics similar to those of indirect lighting discussed in later paragraphs. These forms of lighting are frequently used to obtain the higher illuminances. Care should be taken to limit the luminance of the shielding medium to 80 candelas per square foot or less to prevent direct glare if critical, prolonged seeing is involved. Reflected glare may be a problem with systems employing cellular louvers as the shielding medium, since the images of the light sources above the louvers may be reflected by shiny surfaces at the work plane.

f. Semi-Direct Lighting. The distribution from semi-direct units is predominantly downward (60 to 90 percent), but with a small upward component to illuminate the ceiling and upper walls. The characteristics are essentially the same as for direct lighting, except that the upward component will tend to soften shadows and improve room brightness relationships. Care should be exercised with close-to-ceiling mounting of some types to prevent overly bright ceilings directly above the luminaire. The room utilization factor can approach or even exceed that of well-shielded direct units.

g. General Diffuse Lighting. The lighting system is classified as general diffuse when downward and upward components of light from luminaires are about equal (each 40 to 60 percent of total luminaire output). General diffuse lighting units combine the characteristics of direct and indirect lighting. The room utilization factor is somewhat lower than for direct or semi-direct units, but it is still quite good in rooms with high reflectance surfaces. Brightness relationships throughout the room are generally good, and shadows from the direct component are softened by the upward light reflected from the ceiling.

(1) Direct Glare Control. Excellent direct glare control can be provided by well-shielded units, but short suspensions can result in ceiling luminances that exceed the luminaire

luminances. Close spacings or layouts that locate units so that they are not reflected in the task result in reductions of reflected glare from the downward component.

(2) Pendant Mountings. Luminaires designed to provide a general diffuse or direct-indirect distribution when pendant mounted are frequently installed on, or very close to, the ceiling. These type mountings change the distribution to direct or semi-direct since the ceiling acts as a top reflector redirecting the upward light back through the luminaire. Photometric data, obtained with the luminaire equipped with top reflectors or installed on a simulated ceiling board, should be employed to determine the luminaire characteristics for such application conditions.

h. Direct-Indirect Lighting. Direct-indirect lighting is a special (non-CIE) category within the classification for luminaires which emit very little light at angles near the horizontal. Since this characteristic results in lower luminances in the direct glare zone, direct-indirect luminaires are usually more suitable than general diffuse luminaires which distribute the light about equally in all directions.

i. Semi-Indirect Lighting. Lighting systems which emit 60 to 90 percent of their output upward are defined as semi-indirect. The characteristics of semi-indirect lighting are similar to those of indirect systems, except that the downward component usually produces a luminaire luminance that closely matches that of the ceiling. However, if the downward component becomes too great and is not properly controlled, direct or reflected glare may result. An increased downward component improves utilization of light somewhat over that of indirect lighting. This factor makes somewhat higher illuminances possible with fewer semi-indirect luminaires and without excessive ceiling luminance.

j. Lighting for the Cathode Ray Tube (CRT). Cathode ray tubes are commonplace, with visual display units appearing on the shop floor with ultrasonic equipment, eddy current equipment, video adapters for borescopes and microscopes, etc. Their typically convex surfaces act like curved mirrors that reflect large areas of ceiling, walls, windows, and other room surfaces. If any of these surfaces are intrinsically bright, such as windows and fixtures, or are brightly lighted, their reflected images will reduce the visibility of the information being processed on the screen and annoy the operator. The CRT problem could be solved by turning off all the lights and shading the windows; however, this is usually not practical. Many of the screen reflection problems can be reduced by the following methods:

(1) Screen Orientation. Proper screen orientation or using hoods or anti-reflection screens or filters.

(2) Shades. Using blinds, shades, or dark curtains to help eliminate window brightness.

(3) Dark Colors. Finishing walls and other vertical surfaces in darker colors.

(4) Worker Clothing. Equipping operators with dark smocks.

(5) Luminaires. Using luminaires with dark-tinted lenses, deep parabolic baffles, or parabolic wedge louvers to control fixture brightness. Bright lamp images seen in shiny surfaces directly beneath the fixture can be eliminated by laying a thin plastic diffuser on top of the lens or louver.

(6) Indirect Lighting. When indirect lighting is used to correct CRT reflection problems, levels should not exceed 30 footcandles; otherwise, vertical surfaces get too bright. Ceiling brightness should be uniform with no hot spots. At this level, supplementary task lighting often will be required.

(7) Parabolic Lenses. Parabolic lenses can be used to obtain levels up to about 100 footcandles. If higher levels are needed for specific tasks, supplementary lighting can also be used.

303.-399. RESERVED.

CHAPTER 4. EQUIPMENT USED IN VISUAL INSPECTION

400. GENERAL. The following chapter describes the various aids to vision used in visual inspection. In general, they consist of mirrors, magnifiers, and various schemes for conveying images from inaccessible sources to where they may be seen.

a. Inspection Mirrors. Inspection mirrors are used to view areas that are not in the normal line of sight. Table 4-1 shows some of the typical types of inspection mirrors that are available for inspection of hidden areas.

TABLE 4-1. TYPICAL INSPECTION MIRRORS (Courtesy of McMaster-Carr Supply Company) (Sheet 1 of 2)

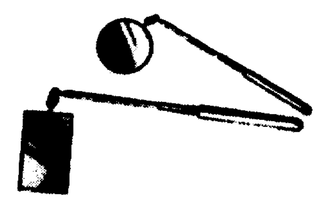
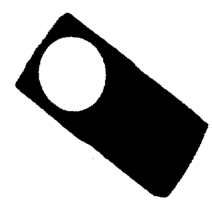
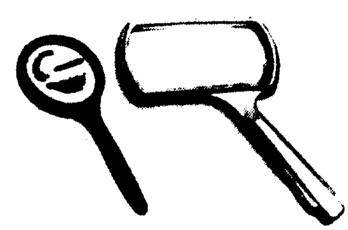
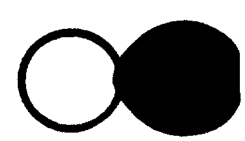
a. Ball-Joint Telescoping Inspection Mirror. This inspection mirror has tempered spring steel, double ball-joint links to allow mirror (true image or magnifying) to move 360º for viewing in any position. Nonrotating inner hex rods on telescoping models prevent mirrors from swinging out of alignment. Replacement mirrors are available.	
b. Spring-Loaded Inspection Mirror. This inspection mirror has a spring-loaded plunger to tilt the mirror 90º. The mirror is returned to the straight position by tripping a locking device. Single-handed operation allows inspection without removing the mirror from the work area.	
c. Telescoping Inspection Mirror with Magnet. This inspection mirror can be used to find lost nuts, bolts, and other small parts and then pick them up with the magnet in the handle. the telescoping handle has a double ball-joint to hold glass mirror at any angle.	
d. Electrical Component Inspection Mirror. This inspection mirror is extra thin so it can be used to inspect under and around small electrical components. The 90-degree mirrors have beveled edges to match inspection surfaces. Handles are spring-mounted.	

TABLE 4-1. TYPICAL INSPECTION MIRRORS (Courtesy of McMaster-Carr Supply Company) (Sheet 2 of 2)

e. Electrically Insulated Inspection Mirror. This inspection mirror is electrically insulated to prevent dangerous shocks or shorts when inspecting near sources of electricity.	
f. Adjustable Angle Illuminated Inspection Mirror. This inspection mirror has a light and adjustable mirror at the tip that can be controlled with the thumb.	
g. Magnetic Base Inspection Mirror. This inspection mirror has magnets in a molded nylon base that allows mounting in the work area. Two ball joints allow adjustment of the glass mirror.	
h. Long Reach Extension Inspection Mirror. This inspection mirror has a nonconducting handle which extends from five to sixteen feet and it has a nine- by nine-inch glass mirror with light.	
i. Suction Cup Inspection Mirror. This telescoping arm inspection mirror attaches with three suction cups to any hard smooth surface. The telescoping arm can be extended up to thirty inches. The four-inch-diameter unbreakable mirror is true image on one side and magnified image on the other.	
j. Illuminated Inspection Mirror. This penlight inspection mirror has a Lucite rod that directs light on an adjustable plastic frame mirror.	

b. Simple Magnifiers. A single converging lens, the simplest form of a microscope, is often referred to as a simple magnifier. Magnification of a single lens is determined by the equation $M = 10/f$, where M is the magnification, f is the focal length in inches, and 10 represents the average minimum distance at which objects can be distinctly seen by the unaided eye. For example, using this equation, a lens with a focal length of 5 inches has a magnification of 2, or is said to be a two-power lens (sometime written 2X). Table 4-2 shows some of the typical types of simple magnifiers that are available.

TABLE 4-2. TYPICAL SIMPLE MAGNIFIERS (Courtesy of McMaster-Carr Supply Company)

a. Folding Case Magnifiers. These magnifiers contain single glass or acrylic plastic lenses which can be combined for magnification from 3 to 20 power. The lenses swing out when needed and the plastic case acts as a handle. Focal lengths vary from 1/2 to 2 1/2 inches depending on lens combination.	
b. Pocket Magnifiers. These magnifiers contain single glass or acrylic plastic lenses mounted in a case that slides open and locks shut to protect the lens when placed in the pocket. Overall size is 1 5/8 inches by 2 1/4 inches. They are available in 3X and 5X with focal length of 3.3 inches and 2 inches.	
c. Round and Rectangular Magnifiers. These magnifiers have a sculptured plastic handle and lens frame and are available with glass or scratch resistant acrylic plastic lenses. The glass lenses have 2X magnification, lens diameters from 2.75 to 5.32 inches and focal lengths from 6 to 13 inches. The acrylic lens have 2.5X to 3X (with a 5X bifocal insert), lens diameters are from 2 inches and focal lengths from 10 to 2 inches.	
d. Attached Case Magnifiers. These magnifiers have an all in one case that protects the lens and serves as a handle. A 2X model has a glass and vinyl case; 3X model has an acrylic lens and plastic case. Lens diameters are 2 inches and 1.5 inches and focal lengths are 5 inches and 2.5 inches.	

(1) Working Distance. The focal length of a simple magnifier and its working distance are approximately the same. For example, suppose that it is desired to examine a part without removing it and the magnifier cannot be placed nearer than 3 inches. Therefore, a magnifier with a working distance (focal length) of at least 3 inches is required. From the equation $M = 10/f$, a three-power lens is required.

(2) Field of View. The field of view is the area seen through the simple magnifier. The diameter of the field of view

of a simple magnifier is less than its focal length. Selection of a magnifier with proper field of view is important. For example, if a large object is to be examined, the time involved using a 20-power magnifier (with a field of view slightly greater than 3/8 inch) would be prohibitive.

(3) Depth of Field. Depth of field is the term used to indicate the distance a magnifier can be moved toward or away from an object, with the object remaining in good focus. At other distances the object is out of focus and not sharply defined. Depth of field varies with the power of the lens and is comparatively greater in lower-power magnifiers, decreasing as the power of the lens increases.

401. MAGNIFYING DEVICES. Some magnifying devices recommended for use in conducting visual inspections include: hand-held magnifiers with single and multiple lenses jeweler's eye loupes, illuminated magnifiers, pocket/desk type microscopes, toolmaker's microscopes, rigid/flexible borescopes, and video imaging systems. These devices are available with numerous features, such as 1 to 2000 power, self-contained illumination, adjustable variable magnification (zoom), stereo viewing, data storage/ transmission, computer generated electronic alignment targets, and measuring capability.

a. Selecting Magnification Power. Magnification power and field of view are interrelated, and, in general, as magnification power is increased, the field of view is reduced. Therefore, it is important to select a magnification power that will provide the proper field of view for the part being inspected. When inspecting a large area, the time involved could be prohibitive if high power magnification (with a small field of view) is used. Therefore, the recommended procedure is to first use low power magnification (with a large field of view), mark questionable areas, and then examine marked areas using high power magnification. The precise relationship between magnification power and field of view of a product is usually specified by the manufacturer.

b. Light Collecting Ability. The detail observed in a magnifier depends on its light collecting ability, which depends on its diameter and focal ratio (focal length divided by diameter).

402. PHOTOGRAPHIC AND VIDEO SYSTEMS. An image on a video monitor or a photograph allows inspectors to share analysis, decisions, knowledge, and skills when making visual inspections. Photographic and video systems are available which attach to the eyepieces of borescopes, fiberscopes, and microscopes for documentation and analysis of visual inspection images. Video systems are also available that have a charge-coupled device (CCD) image sensor at the probe end of the borescope or microscope, which allows wire rather than fiber optic transmission of the image.

a. System Capabilities. Video systems permit video images to be recorded and stored on print or slide film, video cassette recorders, or computer disks. Microprocessors can be used to digitize video images for storage on a computer disk, or for transfer to other sites by modem and telephone lines. Photographic or video recording provides verifiable data for training purposes and for trend monitoring.

b. Typical Systems. Figure 4-1 shows a typical 35-mm camera and adapter installed on a rigid borescope that has a mounting kit to provide a platform for vibration-free photography. Figure 4-2 shows a typical video adapter system for converting a standard flexible or rigid borescope to a video inspection and documentation system. Figure 4-3 shows a block diagram of a typical video inspection, documentation, storage, and transmission system.

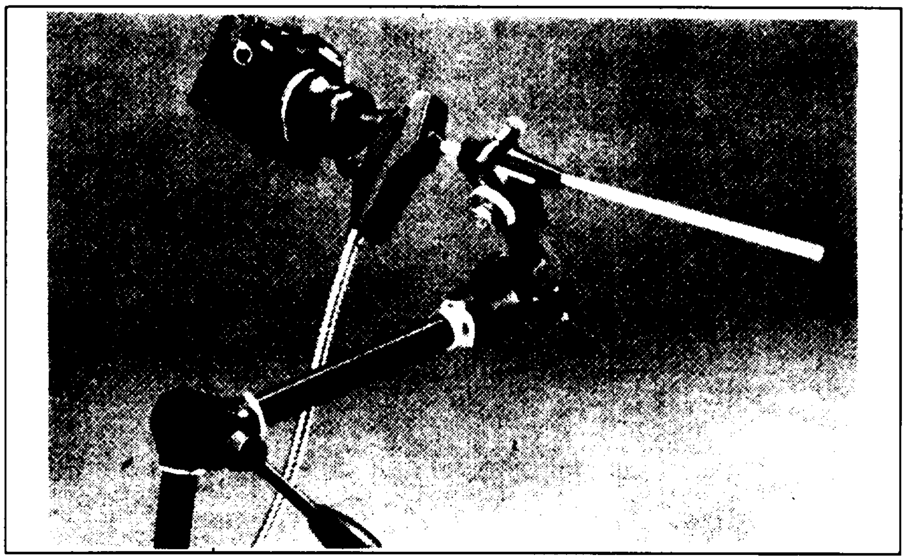


FIGURE 4-1. TYPICAL 35-MM CAMERA AND CAMERA ADAPTER INSTALLATION ON A RIGID BORESCOPE
(Courtesy of Olympus Corporation)

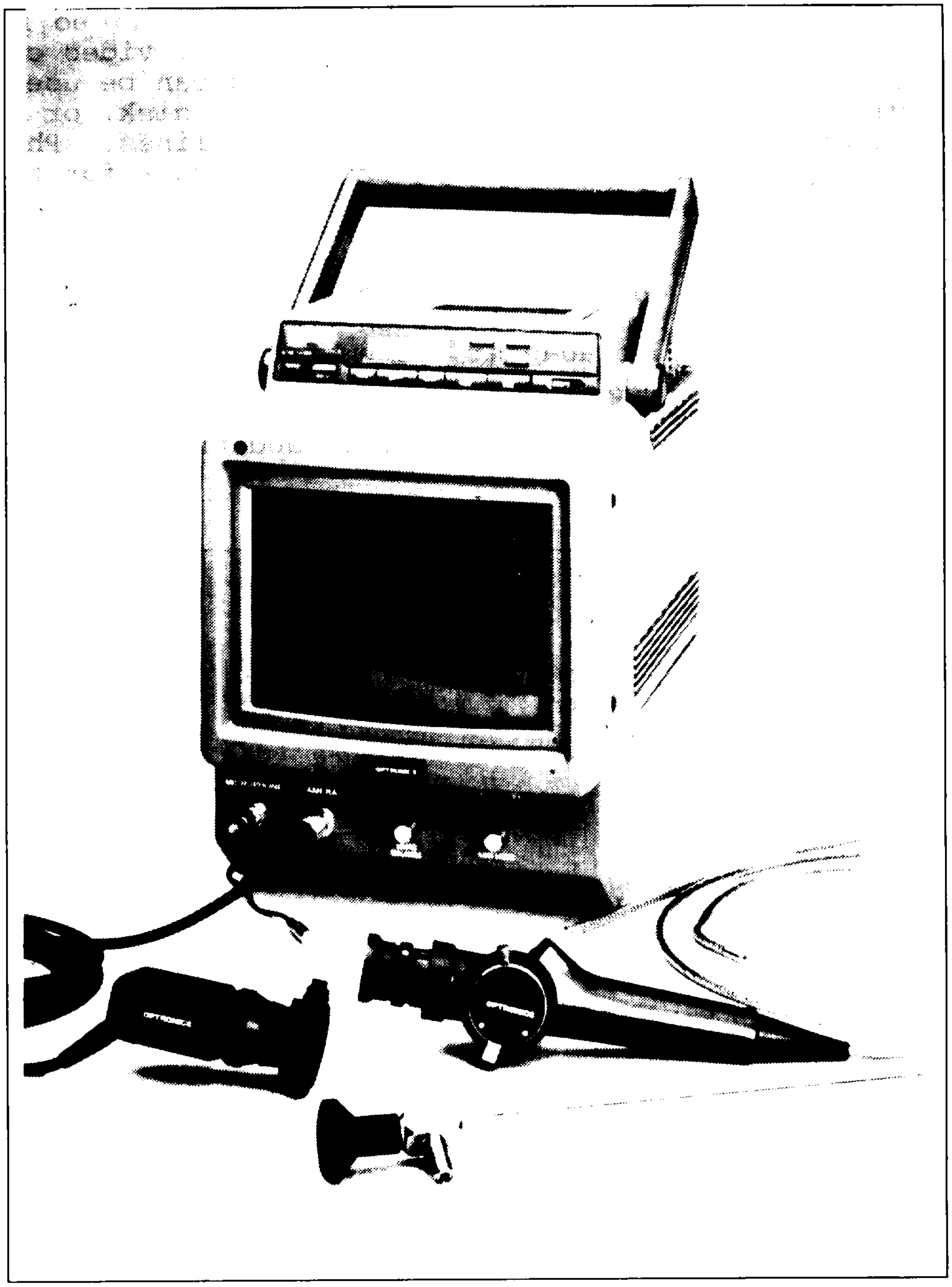


FIGURE 4-2. TYPICAL BORESCOPE VIDEO ADAPTER SYSTEM (Courtesy of Optronics Engineering Corporation)

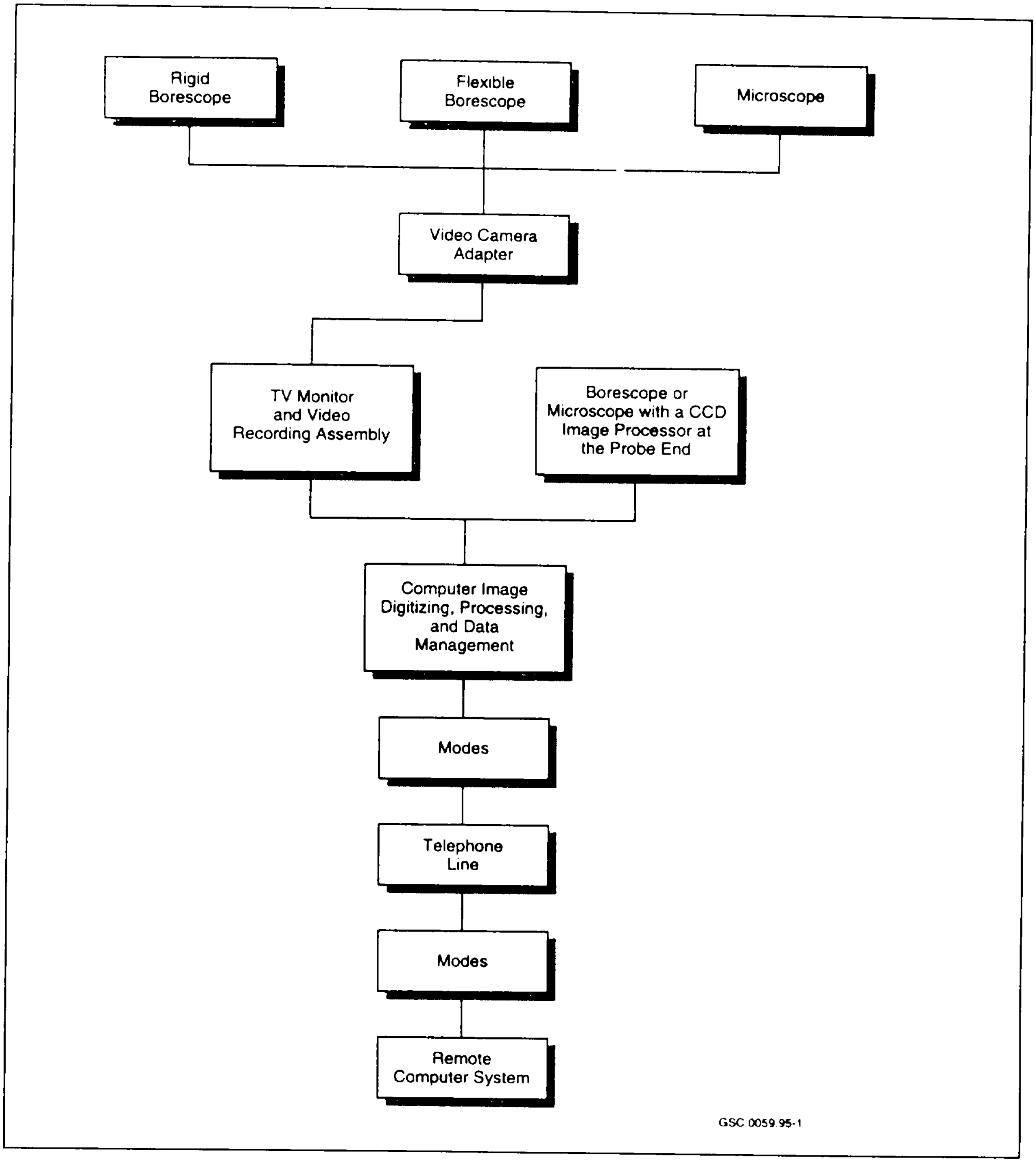


FIGURE 4-3. BLOCK DIAGRAM OF A TYPICAL VIDEO INSPECTION SYSTEM

c. Hand-Held Video Microscope Imaging System. In some video microscope inspection equipment, the camera, lens, and lighting are all integrated into a flexible, hand-held probe that is taken to the item to be inspected (see Figure 4-4). A solid-state CCD sensor is located in the end of the camera head, and various lenses can be attached to the camera head to provide the user with magnifications from 0.7 to 800 power and working distances from contact to 600 mm. The instrument provides a high resolution, full color video image; records the image for later use; is portable; and can be customized for a specific application. The instrument is particularly useful in areas where it is difficult to hold a flashlight and mirror while trying to focus a magnifying glass. Some typical uses for the hand-held video microscope in aircraft maintenance are inspection of aircraft seat tracks for cracks (it is a one-hand operation of placing the video microscope head on the tracks and viewing the screen, where previously a mirror and flashlight were required); inspection of composite-material helicopter rotor leading edges for delamination/damage; inspection of aircraft turbine honeycomb seal rings for defects; and inspection of aircraft rear pressure bulkhead, engine pylon, spar, and main landing gear aft trunnion for defects.

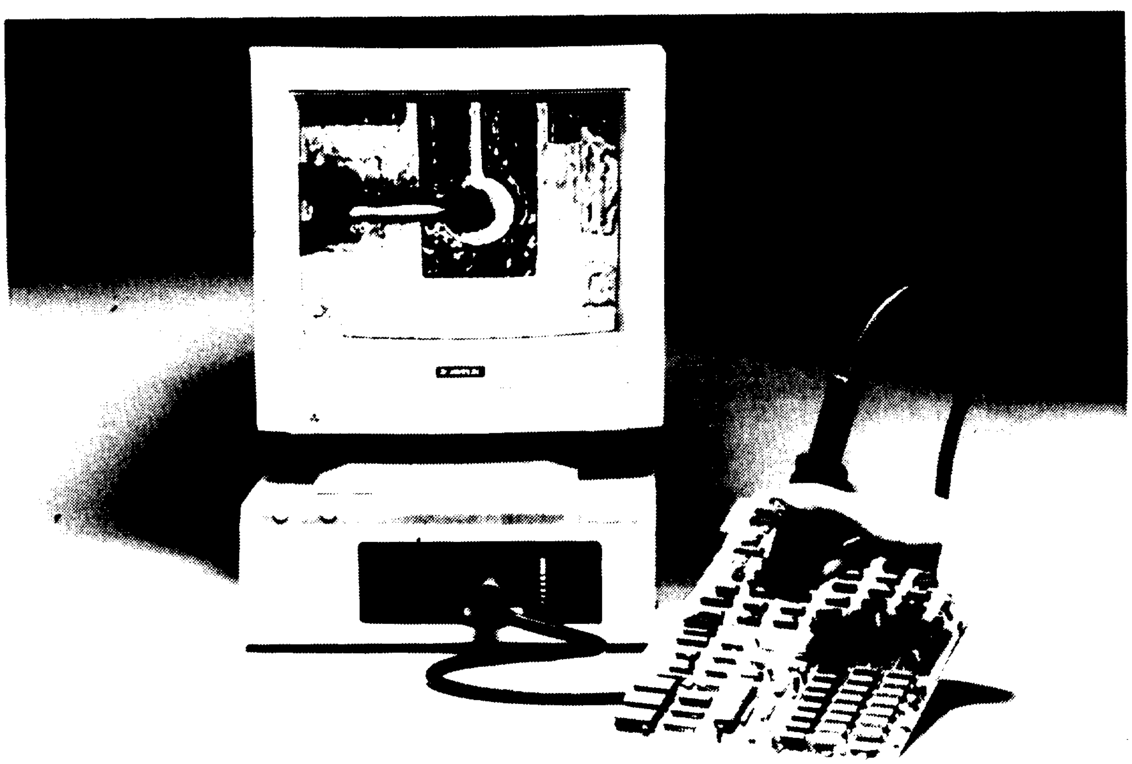


FIGURE 4-4. SCOPEMAN HAND-HELD VIDEO MICROSCOPE IMAGING SYSTEM (Courtesy of Moritex USA, Inc.)

d. Video Measuring Microscope. Video measuring microscopes (see Figure 4-5) are also available. They use a high-quality zoom microscope (magnification from 8 to 1630 power) with joy-stick control in conjunction with a high-resolution color video and computer. The SmartScope system contains a set of computer-generated electronic targets and charts for superimposing on the color video image to match the feature being measured. A graphics model that looks like a blueprint of the part is built by SmartScope software as each measurement is completed. The graphics model is stored on a hard disk and can be displayed or printed at any time. Some examples of the use of video measuring microscopes for aircraft maintenance are measurement of hole diameter and locations on castings after they have been reworked and measurement of dimensions of used mechanical parts to determine if they are still serviceable.

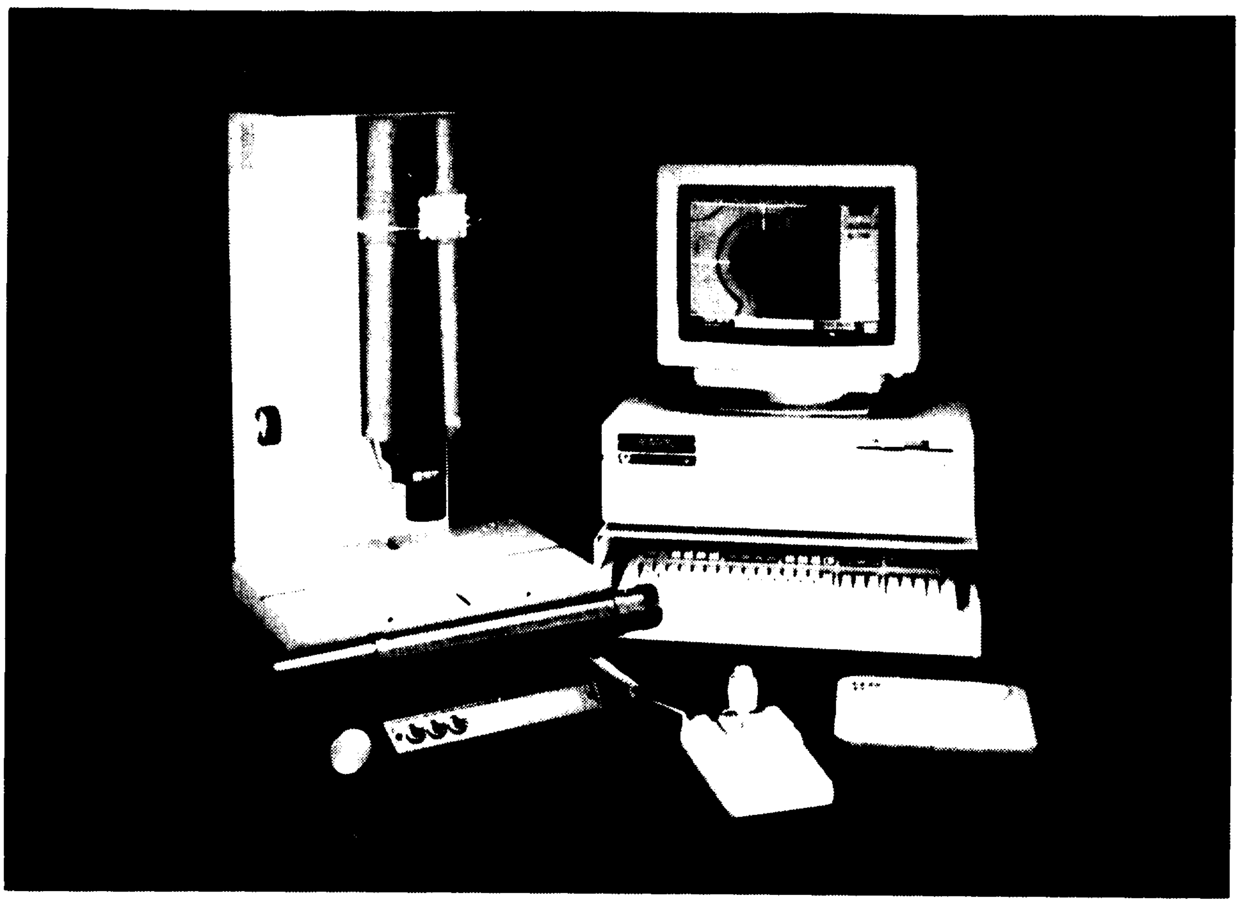


FIGURE 4-5. SMARTSCOPE VIDEO MEASURING MICROSCOPE SYSTEM
(Courtesy of Optical Gaging Products, Inc.)

403. OPTICAL COMPARATORS. Optical comparators are devices that project a magnified silhouette of a small part onto a large projection screen, which is then compared against a magnified outline drawing of the part being inspected. They are used in aircraft maintenance for assessing parts conformity. Figure 4-6 shows a typical schematic of an optical comparator. Optical comparators are available with numerous options, such as screen sizes from 14 to 30 inch diameter, magnifications from 5 to 500 power, computerized control of measurement and movement, computer statistical analysis of data, part programming from blueprint (off-line or pantograph, 0.00005-inch measurement and one minute of arc resolution), and automatic centerline system for detection of shadow edges. Parts with recessed contours can also be measured on optical comparators by using a pantograph. One arm of the pantograph is a stylus that traces the recessed contour of the part, and the other arm carries a follower that is visible in the light path. As the stylus moves, the follower projects a contour on the screen. Optical comparators typically are used to measure threads, gear teeth, hole diameters, distance between holes, angles, and tapers. Figure 4-7 shows a typical optical comparator. Some examples of the use of an optical comparator for aircraft maintenance are measuring dimensions on grinding wheels that are used to rework aircraft turbine blades (if contact type measurements were made in this application, the measuring tools would be damaged by the grinding wheel abrasive); measurement of hole diameter and locations on gearbox castings after rework; and measurement of radii on used constant-speed drive shafts to verify that the shear sections would meet new part requirements.

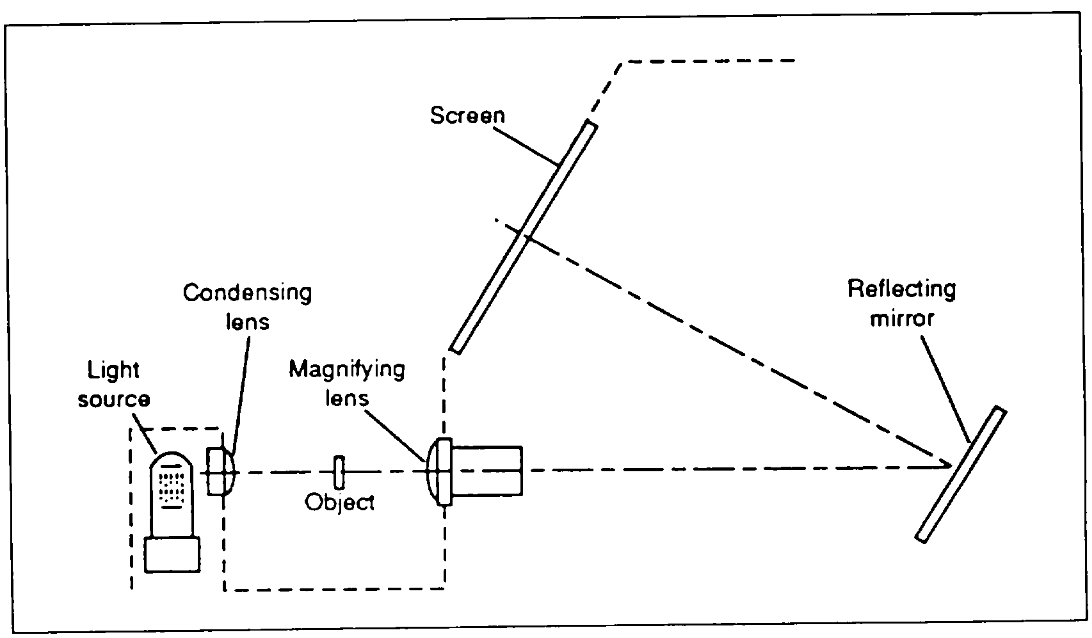


FIGURE 4-6. SCHEMATIC OF AN OPTICAL COMPARATOR

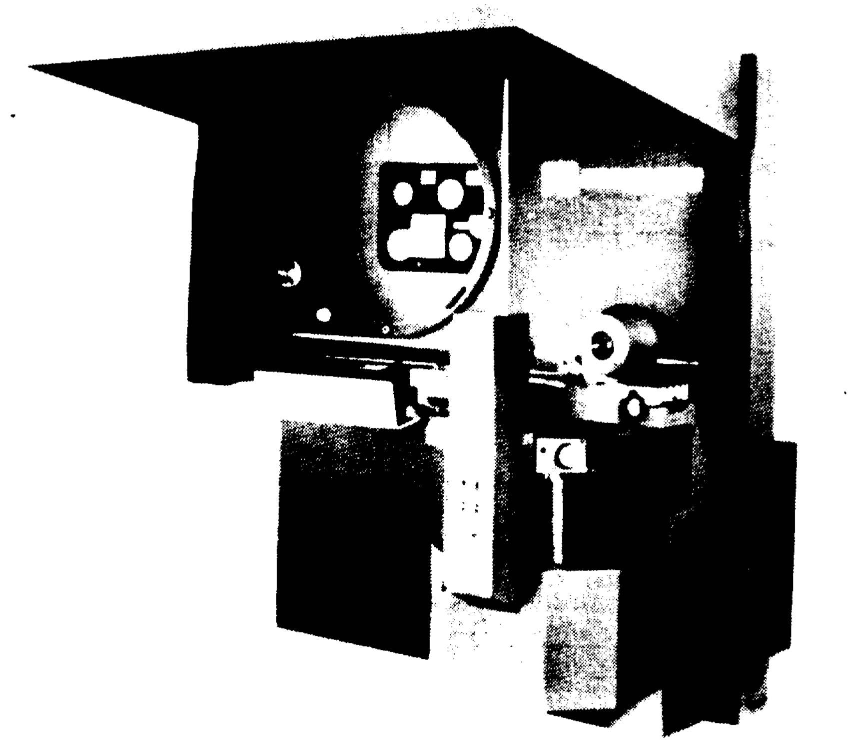


FIGURE 4-7. TYPICAL OPTICAL COMPARATOR
(Courtesy of Optical Gaging Products, Inc.)

404. BORESCOPES. A borescope is a long, tubular, precision optical instrument, with built-in illumination, designed to allow remote visual inspection of internal surfaces, or otherwise inaccessible areas. The tube, which can be rigid or flexible with a wide variety of lengths and diameters, provides the necessary optical connection between the viewing end and an objective lens at the distant, or distal, tip of the borescope. Rigid and flexible borescopes are available in different designs for a variety of standard applications, and manufacturers also provide custom designs for specialized applications. Figure 4-8 shows three typical designs of borescopes.

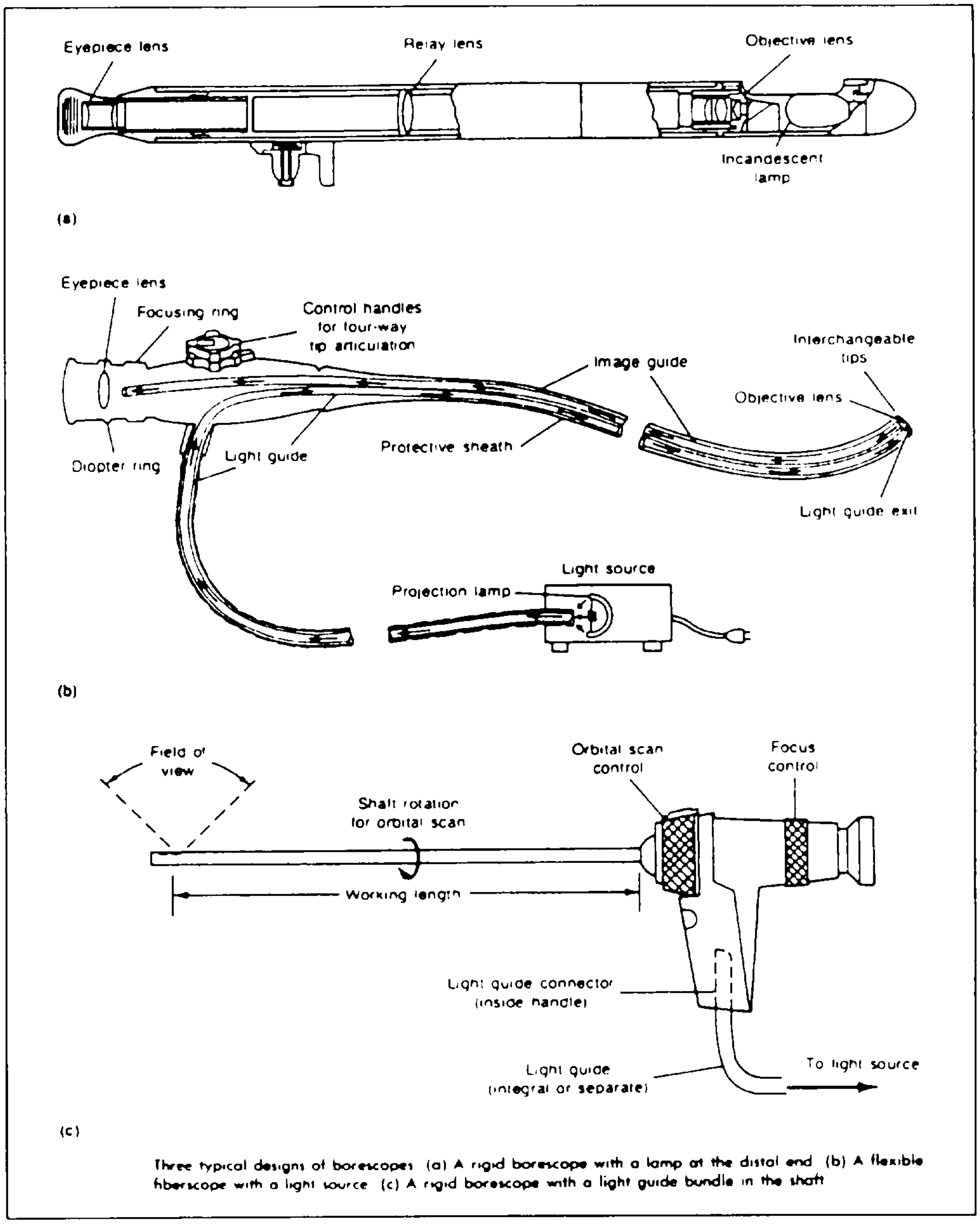


FIGURE 4-8. THREE TYPICAL DESIGNS OF BORESCOPES
(Courtesy of ASM International)

a. Borescope Uses. Borescopes are used in aircraft/engine maintenance programs to reduce or eliminate the need for costly teardowns. Aircraft turbine engines have access ports that are specifically designed for borescopes. Borescopes are also used extensively in a variety of aviation maintenance programs to ensure the airworthiness of difficult-to-reach components. Borescopes typically are used to inspect interiors of hydraulic cylinders and valves for pitting, scoring, porosity, and tool marks; inspect for cracked cylinders in aircraft reciprocating engines; inspect turbojet engine turbine blades and combustion cans; verify the proper placement and fit of seals, bonds, gaskets, and subassemblies in difficult-to-reach areas of aircraft and aeronautical equipment; and assess Foreign Object Damage (FOD) in aircraft, airframe, and powerplants. Borescopes may also be used to locate and retrieve foreign objects in engines and airframes.

b. Optical Designs. Typical designs for the optical connection between the borescope viewing end and the distal tip are as follows: rigid tube with a series of relay lenses, flexible or rigid tube with a bundle of optical fibers, and flexible or rigid tube with wiring that carries the image signal from a CCD imaging sensor at the distal tip. These designs can have either fixed or adjustable focusing of the objective lens at the distal tip. The distal tip also has prisms and mirrors that define the direction and field of view (Figure 4-9). A fiber-optic light guide with white light is generally used in the illumination system, but ultraviolet light can also be used to inspect surfaces treated with liquid fluorescent penetrant or to inspect for contaminants that fluoresce. Some videoscopes with long working lengths use light-emitting diodes at the distal tip for illumination.

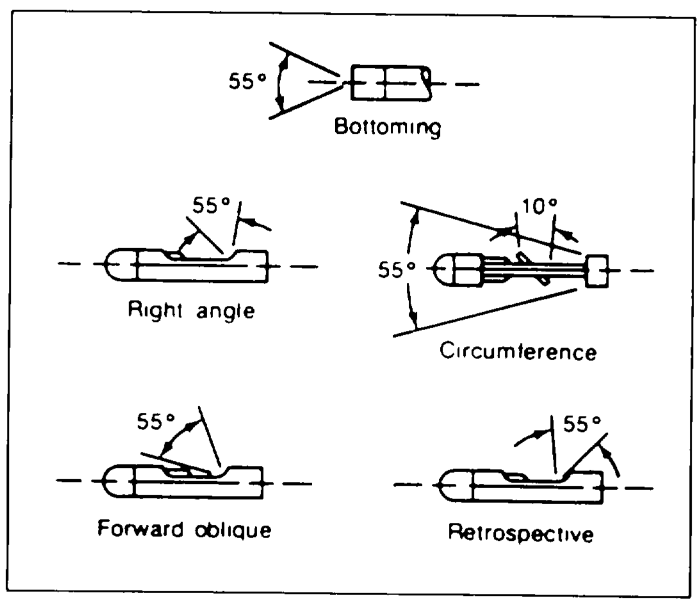


FIGURE 4-9. TYPICAL DIRECTIONS AND FIELD OF VIEW OF RIGID BORESCOPES (Courtesy of ASM International)

c. Borescope Selection. Flexible and rigid borescopes are available in a wide variety of standard and customized designs, and several factors can influence the selection of a scope for a particular application. These factors include focusing and resolution, illumination, magnification and field of view, working length, direction of view, and environment.

(1) Focusing and Resolution. In general, the optical quality of a rigid borescope improves as the size of the lens increases; consequently, a borescope with the largest possible diameter should be used. If portions of long objects are at different planes, the borescope should have sufficient focus adjustment to achieve an adequate depth of field. If the borescope has a fixed focal length, the object will be in focus only at a specific lens-to-object distance. To allow the observation of surface detail at a desired size, the optical system of a borescope should also provide adequate resolution and image contrast. If resolution is adequate, but contrast is lacking, detail cannot be observed. For fiberscopes, the resolution is dependent on the accuracy of alignment and the diameter of the fibers in the image bundle. Smaller diameter fibers provide more resolution and edge contrast when combined with good geometrical alignment of the fibers.

(2) Illumination. The amount of illumination depends on the diameter of the light guide bundle; therefore, it is desirable to use the largest diameter possible. The required intensity of the light source is determined by the reflectivity of the surface, the area of surface to be illuminated, and the transmission losses over the length of the scope. Rigid borescopes with a lamp at the distal end provide the greatest amount of illumination over the widest area at working lengths greater than 20 feet; however, the heat generated by the light source can damage some materials. Fiber-optic illumination is usually brighter than a lamp at the distal end with scope working lengths less than 20 feet and is suitable for heat-sensitive applications when filters are used to remove infrared wavelengths.

(3) Magnification and Field of View. Magnification and field of view are interrelated, and as magnification is increased, the field of view is reduced. The precise relationship between magnification and field of view is generally specified by the product manufacturer. The degree of magnification in a particular application is determined by the field of view and the distance from the objective lens to the object. The magnification increases when either the field of view or the lens-to-object distance decreases.

(4) Working Length. The working length can sometimes dictate the use of a particular type of borescope. For example, a rigid borescope with a long working length may be limited by the need for additional supports. In general, videoscopes allow a longer working length than fiberscopes.

(5) Direction of View. The selection of a viewing direction is influenced by the location of the access port in relation to the object to be observed. Flexible fiberscopes or videoscopes, because of their articulating tip, are often adequate with either a side or forward viewing tip. Circumferential or panoramic heads are designed for the inspection of tubing or other cylindrical parts. A centrally located mirror permits right angle viewing of an area just scanned by the panoramic view. The forward viewing head permits the inspection of the area directly ahead of the viewing head and is commonly used when examining facing walls or the bottoms of blind holes and cavities. Forward-oblique heads bend the viewing direction at an angle to the borescope axis, permitting the inspection of corners at the end of a bored hole. Retrospective viewing heads bend the cone of view at a retrospective angle to the borescope axis, providing a view of the area just passed by the advancing borescope and are especially suited for inspecting the inside corners of valve body and actuating cylinder castings.

(6) Environment. Flexible and rigid borescopes can be manufactured to withstand a variety of environments. Although most borescopes can operate at temperatures from -30 to 150 degrees F, specially designed borescopes can be used at temperatures to 3500 degrees F. Borescopes can also be manufactured for use in liquid media. Special borescopes are required for use at pressures above ambient and in atmospheres exposed to radiation. Radiation can cause lenses and fiber-optic bundles to turn brown. When a borescope is used in atmospheres exposed to radiation, quartz fiberscopes are generally used. Scopes used in a gaseous environment should be made explosion-proof to minimize the potential of an accidental explosion.

d. Rigid Borescopes. Rigid borescopes are generally used in aircraft maintenance applications where there is a straight line access path to the area to be inspected. Some typical uses for rigid borescopes in aircraft maintenance are inspection of landing gear actuators and struts for corrosion; cracks and scratches on bore walls; inspection for corrosion and cracks of wing stringers, wing attachment fittings, spars, and other aircraft structural members; inspection of engine cylinder sleeves, pistons, and valves for damage; and inspection of aircraft turbines for cracks, corrosion, damage by foreign objects, and erosion. Rigid borescope sizes range in lengths from 2 inches to over 100 feet and in diameters from 0.035 to 2.75 inches. Magnification is usually 3 to 4 power, but powers up to 50 are available. They are available with fixed and adjustable focus eyepiece. The illumination system is either an incandescent lamp located at the distal end or a light-guide bundle made from optical fibers that conducts light from an external source. The fiber-optics, light-guide bundle has no electrical contacts at the distal end and produces cold light to minimize explosion hazards. Rigid borescopes are available with a variety of viewing heads for selection according to the application. They generally have a 55-degree field of view although fields of view can range from 10 to 90 degrees. The distal tips are generally not interchangeable, but some models, such as the extendible borescopes, can have interchangeable distal tips. Some rigid borescopes have the capability to rotate the optical shaft from 120 to 370 degrees for scanning purposes, and others have movable prisms at the tip for longitudinal scanning.

(1) Basic Design. The rigid borescope typically has a series of achromatic relay lenses in the optical tube. These lenses preserve the resolution of the image as it travels from the objective lens to the eyepiece. The tube diameter of these borescopes ranges from 0.035 to 2.75 inches. The illumination system can be either a distal lamp or a light-guide bundle, and the various features may include rotating optical shaft, various viewing heads, and adjustable focusing of the objective lens.

(2) Micro-borescopes. Micro-borescopes are small-diameter borescopes having an integral light-guide bundle and a one-piece rod lens for maximum resolution with a minimum diameter. Some typical uses for micro-borescopes in aircraft maintenance are inspection for damage within fuel nozzles, electronic components, instruments, hydraulic components, castings, and other miniature equipment. The lengths of micro borescopes range from 2 to 32 inches, and the diameters range from 0.020 to 0.125 inch. They are available with forward, forward oblique, and right angle views; support stands with micrometer adjustable fixturing; photo and video adapters; up to 30-power magnification; and fixed or ocular focus. Figure 4-10 shows a typical micro-borescope.

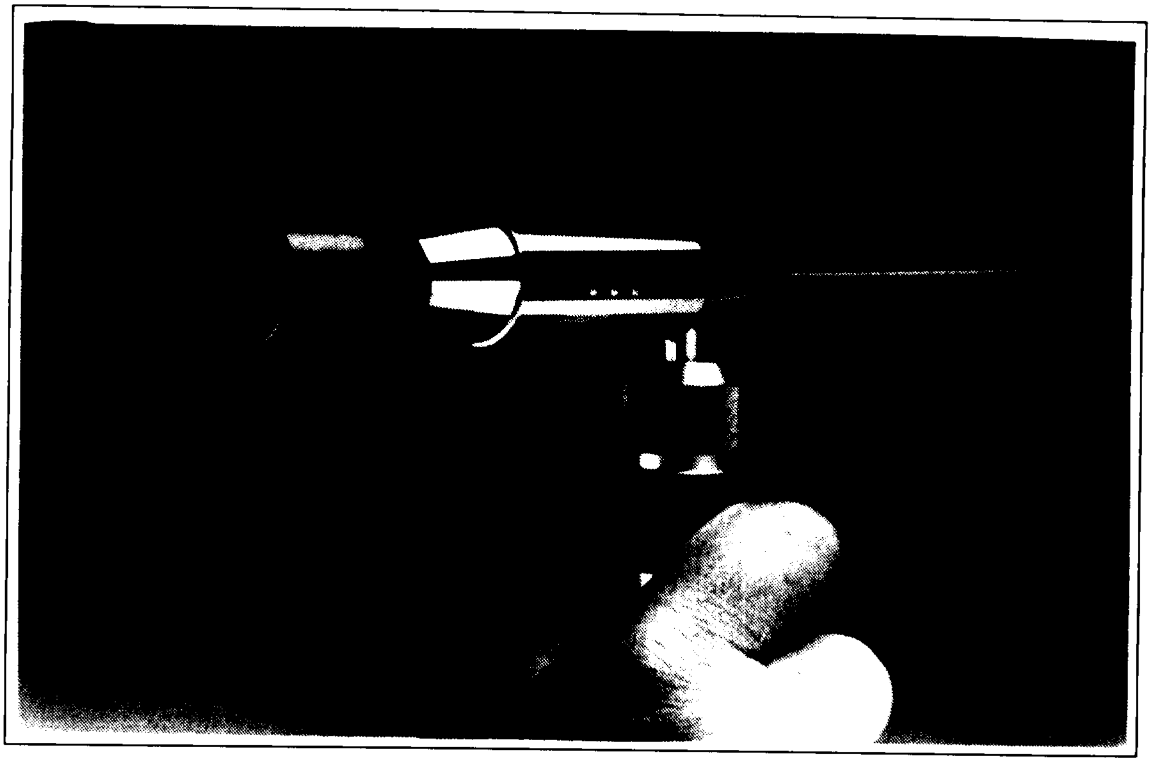


FIGURE 4-10. TYPICAL MICRO-BORESCOPE (Courtesy of Industry Technology, Inc.)

(3) Extendible Borescopes. Extendible borescopes allow the user to vary the length of the borescope tube by inserting extension tubes. Some typical uses for rigid extendible borescopes in aircraft maintenance are inspection for damage within turbine engine combustion cases and inspection for cracks in aircraft rear pressure bulkheads. Extendible borescopes are available with either a fiber-optic light guide or an incandescent lamp at the distal end. Extendible borescopes with an integral lamp have a maximum length of about 100 feet. Extendible borescopes with a light-guide bundle are available with smaller tube diameters, but have shorter maximum lengths (approximately 30 feet). Extendible borescopes allow one borescope to do the work of several different borescopes. Therefore, when feasible for the inspection tasks involved, they can have the advantage of economy, adaptability, and less bulk and weight for easy transportation and use over the purchase and use of a different borescope for each inspection task. Interchangeable viewing heads are available for extendible borescopes. Figure 4-11 shows a typical extendible borescope.

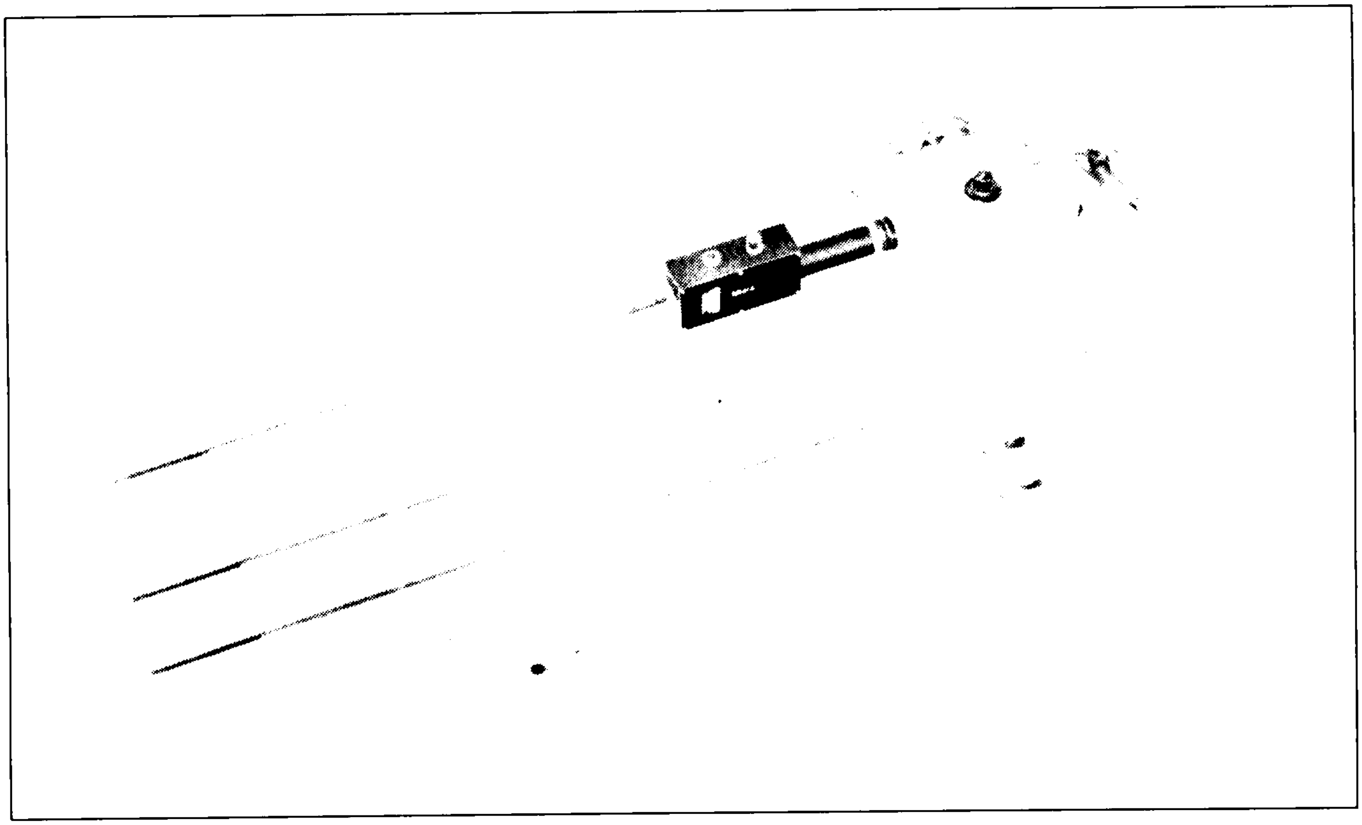


FIGURE 4-11. TYPICAL EXTENDIBLE BORESCOPE
(Courtesy of Titan Tool Supply Company, Inc.)

(4) Endoscopes. The endoscope is much like a borescope with a high-intensity light source, except that it has a superior optical system which remains constantly in focus from about 4 mm (0.16 inch) to infinity. Actually, when the tip is about 4 mm from the surface, a magnification of about 10X is achieved. Endoscopes are available in diameters down to 1.7 mm (0.07 inch) and in lengths from 100 to 150 mm (4 to 6 inches).

(5) Mirror Adapters. Mirror adapters can be used to convert a direct-viewing borescope into a side-viewing borescope. A mirror adapter is designed to fit over the tip of the borescope and reflect an image from the side of the borescope. However, there is some reduction in resolution and image contrast; therefore, not all applications are suitable for this device. A side, forward oblique, or retrospective viewing head provides better resolution and a higher degree of image contrast than a direct-viewing borescope with a mirror adapter. A mirror adapter also produces an inverse image and can produce unwanted reflections from the shaft.

(6) Scanning. Some rigid borescopes have the ability to scan longitudinally along the axis of the shaft. A movable prism with a control at the handle accomplishes this scanning. Typically, the prism can shift the direction of view through an arc of 120 degrees. Figure 4-12 shows a typical scanning borescope.

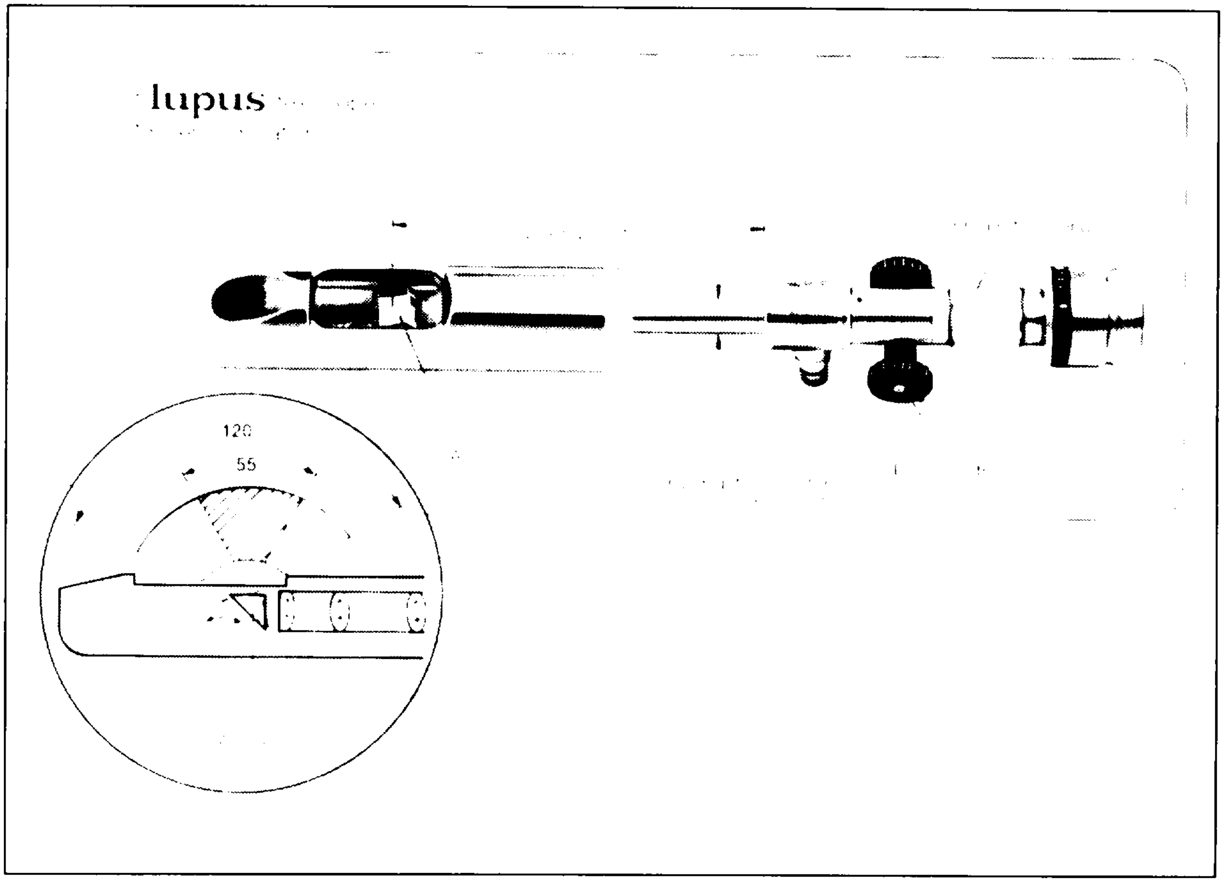


FIGURE 4-12. TYPICAL SCANNING BORESCOPE
(Courtesy of Richard Wolf Medical Instruments Corporation)

(7) Zooming Borescopes. This instrument does not entirely fit the definition of a rigid borescope; however, it is used for inspection of bores and cavities. The zooming borescope (see Figure 4-13) can be used in aircraft maintenance for checking the whole interior surface of tubing and bores for surface finish, cracks, dirt, weld cracks, porosity, etc. It can also be used for checking the finish and chamfer on interior "O" ring grooves and keyways. It is 3/4 inch in diameter and 4 inches long when fully extended and contains an objective lens that magnifies outward in a "V" shape configuration (fisheye lens). It can be used on holes from 3/16 to 5 inch diameter. The whole in-

terior diameter will be in focus at all times. On larger diameters, the instrument would have to be tipped slightly to focus on a specific area of sidewall. The instrument is suitable for viewing parts from 1 inch to 20 feet in length. The focus can be adjusted by holding the instrument in one hand and turning the zoom with the other hand for sharper definition of any depth of field. The area is sharp and in focus at any given focal plane and will vary from about 6 inches to 5 feet, depending on the length of the part and distance from the instrument. For more detail beyond 5 feet, a magnification booster is available. The zooming borescope does not have its own light source, but relies on existing ambient light. Unless the part is very small in diameter, or standard room illumination is poor, no additional light source is necessary. Should additional light be necessary, an inspection flashlight (see Table 3-8) can be held against the other end of the part.

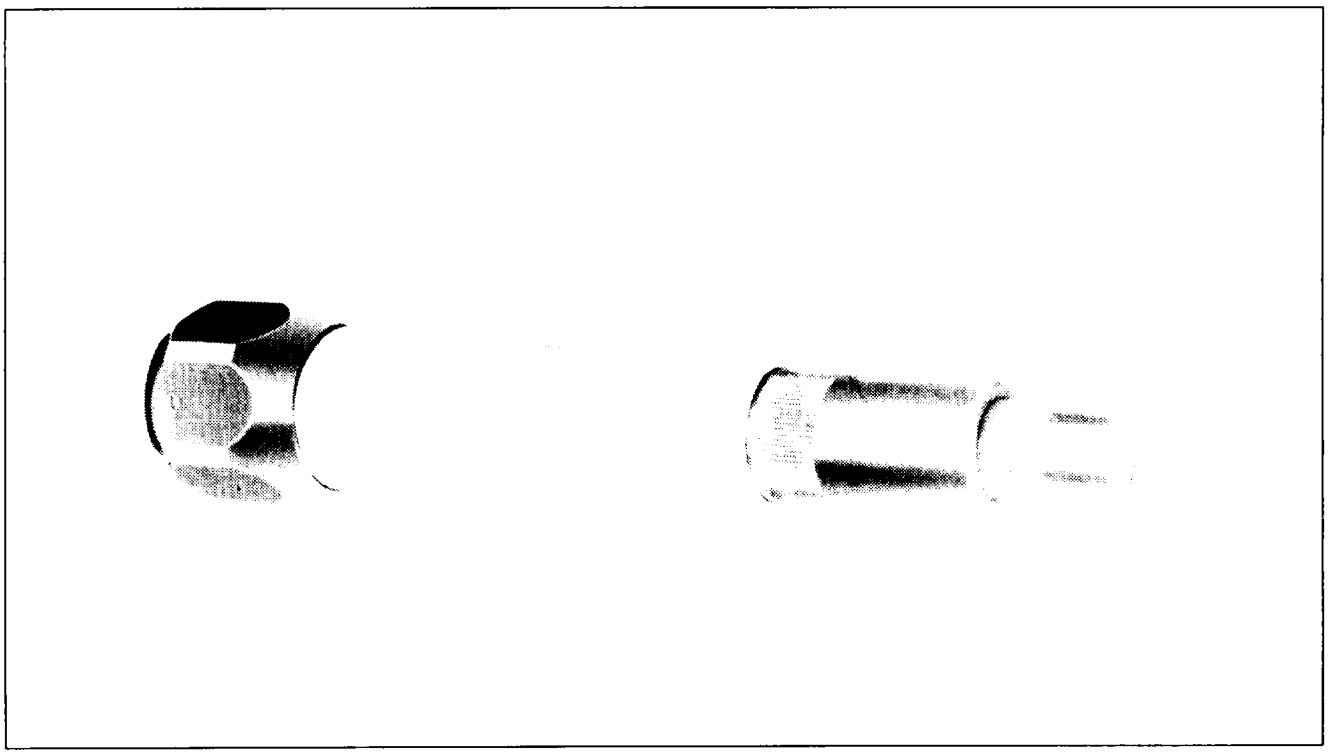


FIGURE 4-13. ZOOM-A-BORE INSPECTION INSTRUMENT WITH MAGNIFICATION BOOSTER ATTACHED
(Courtesy of Titan Tool Supply Company, Inc.)

(8) Micro-Bore Viewing System. Small area borescope viewing systems exist for optical checking of bores and cavities (see Figure 4-14). This system does not fit the definition of a rigid borescope; however, it is used for inspection of bores and cavities. The system was designed to overcome the lighting limi-

tations of some of the micro-borescopes and will not break as easily as the small-diameter borescope probes. This optical device in the illustration comprises 17 different lenses on a rotary system, each with a predetermined focal length (minimum of 0.020 inch to a maximum of 10 inches). It can be used for the internal viewing of micro-bores, tubes, and cavities from 0.039 to 0.315 inch diameter, with depths up to 10 inches. The illumination system is adjustable and contains a 2.5 volt Halogen light bulb. For deep cavities, additional illumination may be necessary, which can be provided by a small diameter inspection light.

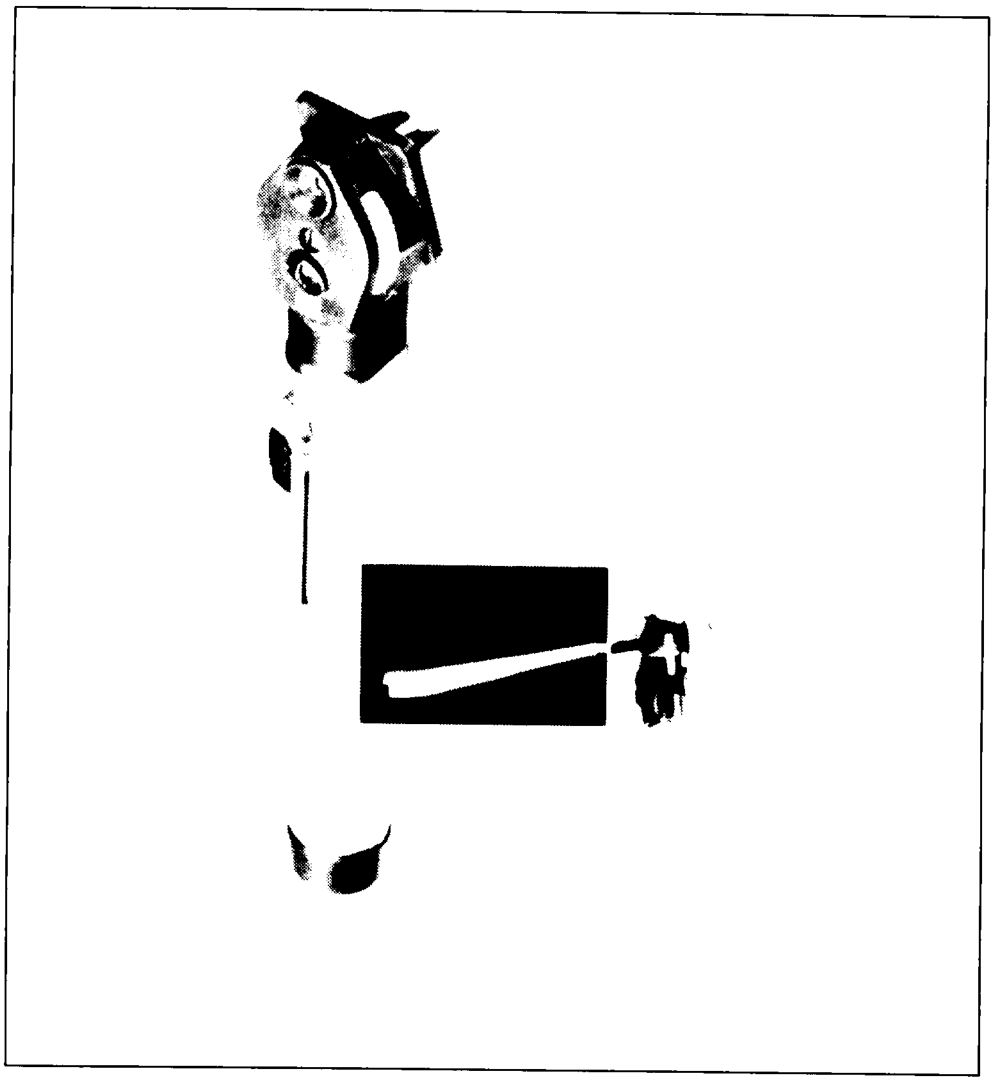


FIGURE 4-14. MICRO-BORE VIEWING SYSTEM (Courtesy of Titan Tool Supply Company, Inc.)

The micro-bore viewing system can be used in aircraft maintenance for checking the inside of small tubes, miniature drilled, bored, and ground holes for surface finish, cracks, dirt, weld cracks, porosity, etc. It can also be used for inspecting the inside of miniature holes in turbine blades and valve bodies.

(9) Mirror Tube Viewing Systems. These systems allow the viewing of small holes and cavities and are meant to be inexpensive alternatives to a rigid borescope for some applications. The system shown in Figure 4-15 allows the viewing of holes and cavities to a depth of 2 inches with 5-power magnification without any attachments. Included with the unit are two separate twist-on mirror tubes, a 0.196 inch diameter, with a viewing depth of 1 inch, and 0.236 inch diameter, which allows a viewing depth of 1.2 inches. Illumination is provided by a miniature Halogen light bulb projecting the illumination directly on the axis down the hole. Powered by two AA batteries.

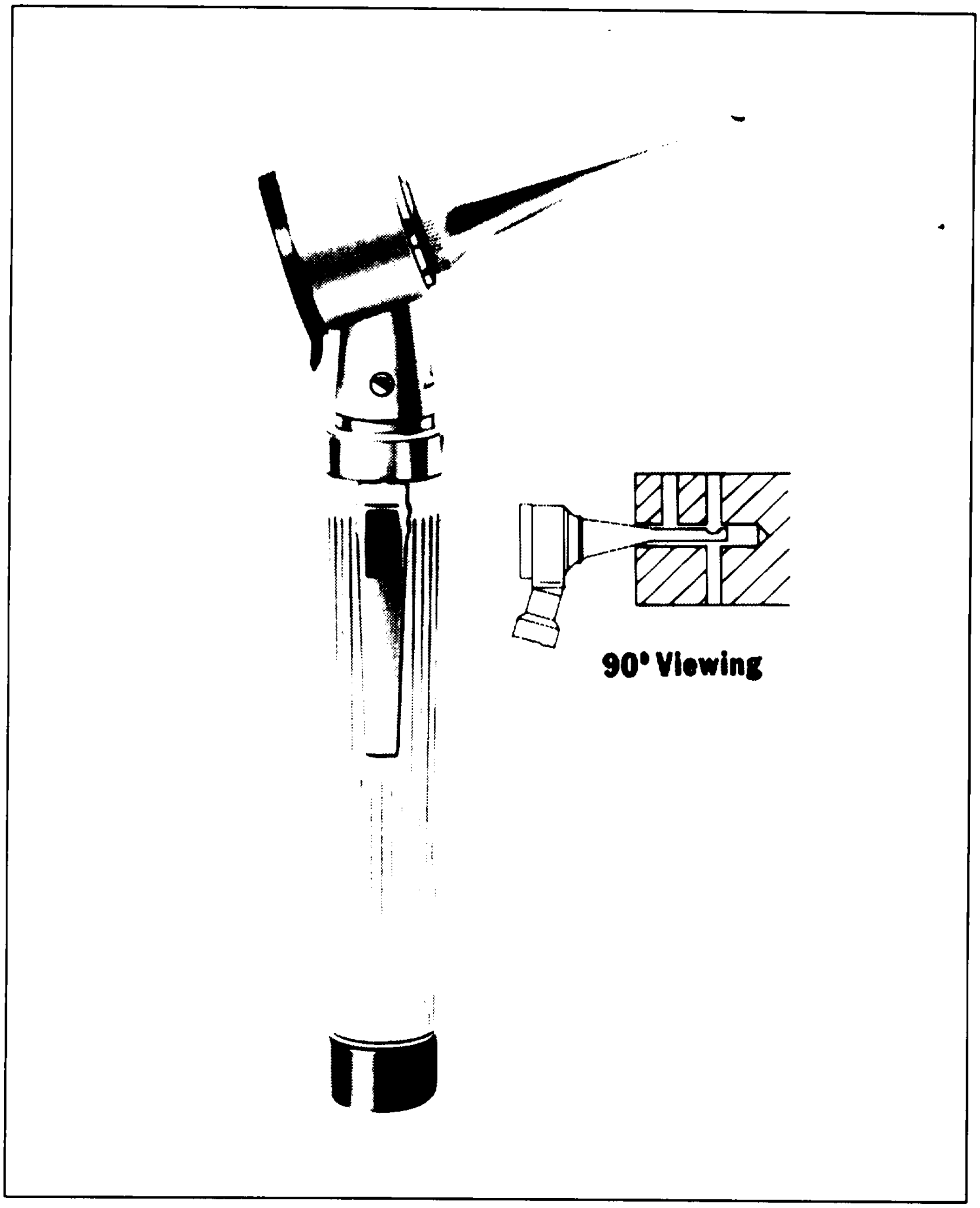


FIGURE 4-15. MIRROR TUBE VIEWING SYSTEM (Courtesy of Titan Tool Supply Company, Inc.)

The mirror viewing system shown in Figure 4-16 is for viewing holes up to 68 inches in depth. The main probe can be 4 to 20 mm in diameter. The field of view is 30 to 70 degrees.

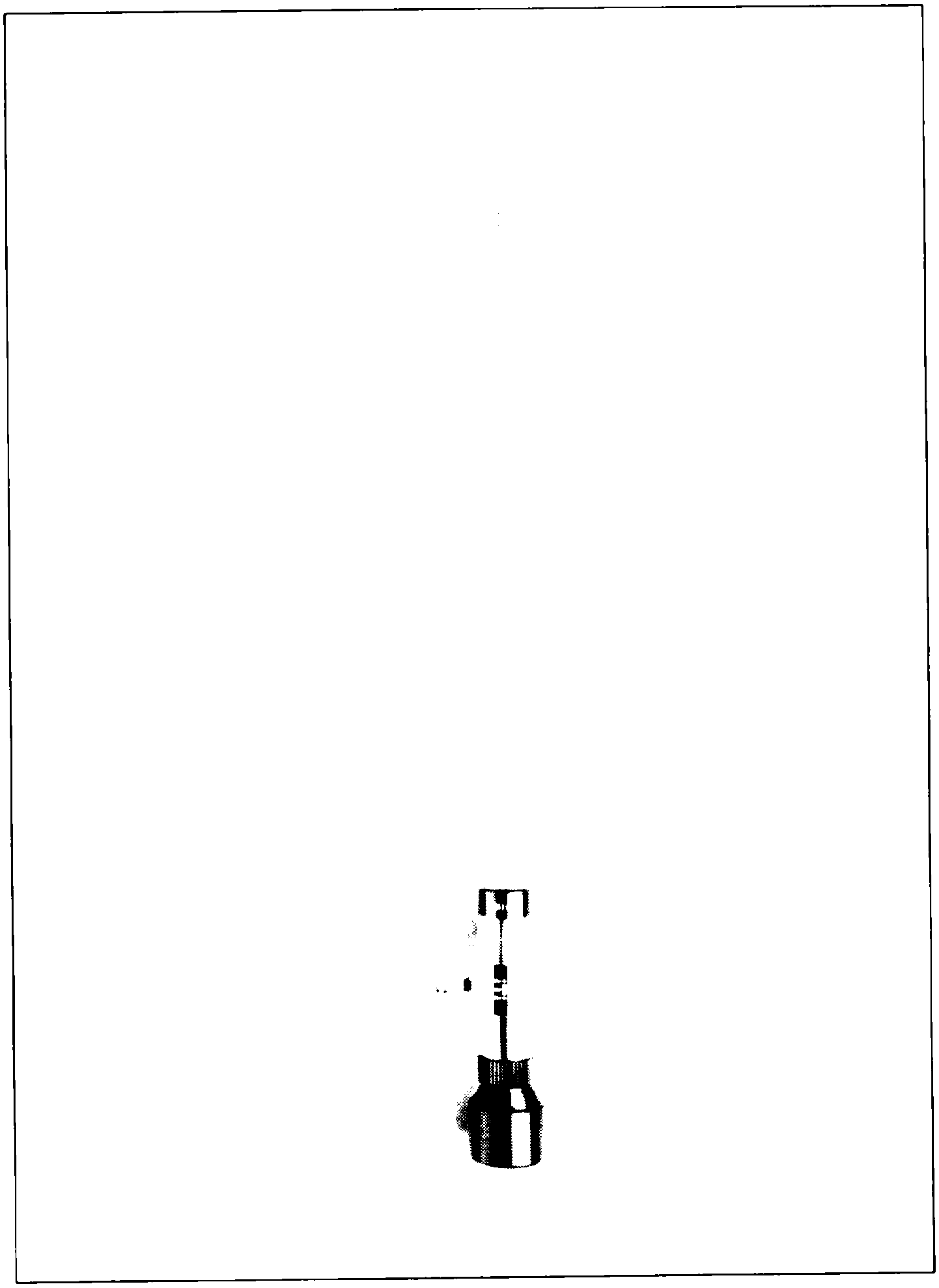


FIGURE 4-16. DEEP-HOLE MIRROR VIEWING SYSTEM (Courtesy of Instrument Technology, Inc.)

e. Flexible Borescopes. Flexible borescopes are generally used in applications that do not have a straight line access path to the area to be inspected. Some typical uses of flexible borescopes in aircraft maintenance are inspection of corrosion, cracks, and scratches on bore walls of castings; inspection for corrosion and cracks of wing stringers, wing attachment fittings, spars, and other aircraft structural members; inspection of engine cylinder sleeves, pistons, and valves for damage; and inspection of aircraft turbines for cracks, corrosion, damage by foreign objects, and erosion. The two types of flexible borescopes are flexible fiberscopes and flexible videoscopes. Figure 4-17 shows some typical flaws seen through a flexible fiberscope.

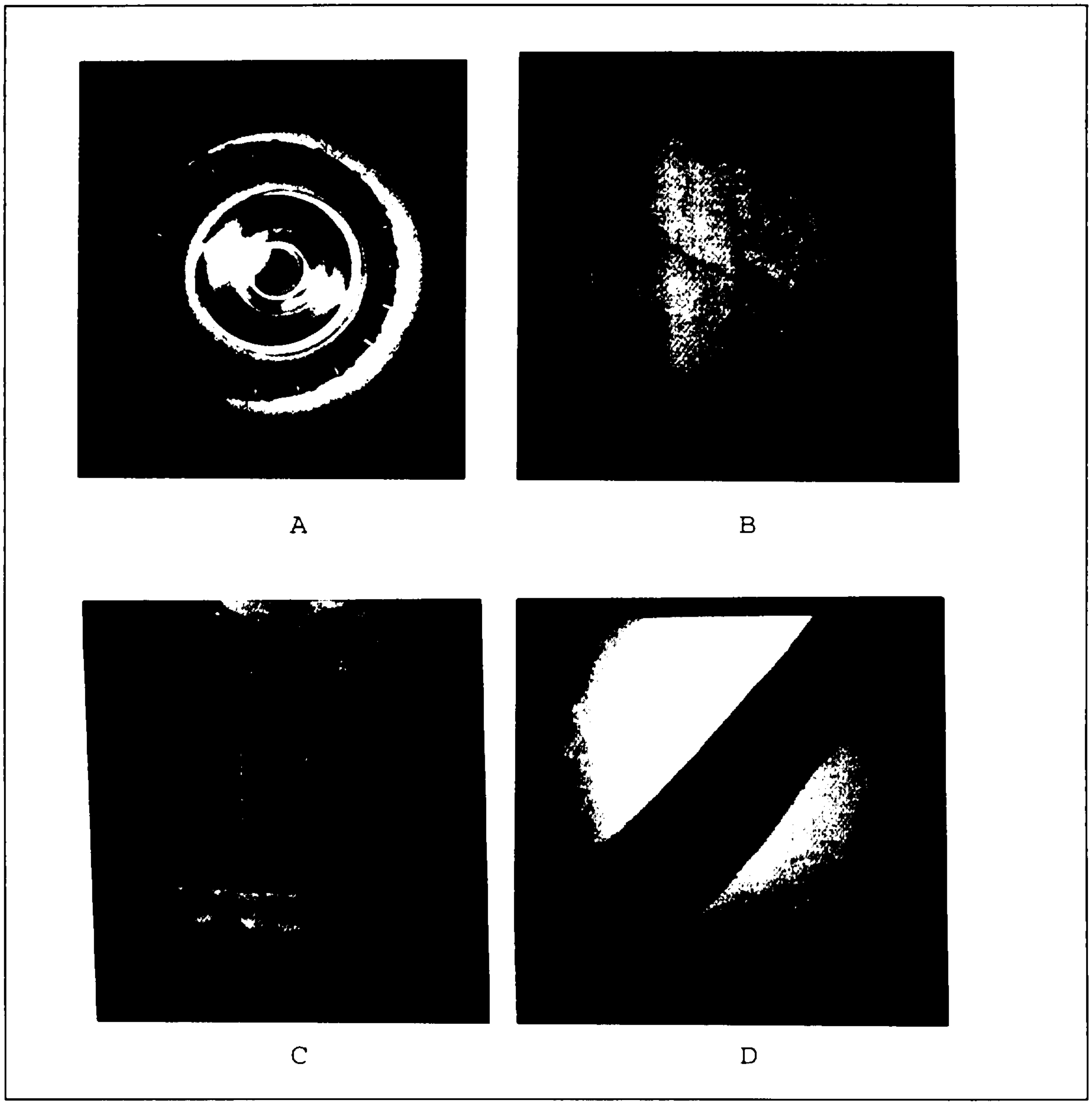


FIGURE 4-17. TYPICAL FLAWS SEEN THROUGH A FLEXIBLE FIBERSCOPE
(Courtesy of Olympus Corporation)

(1) Flexible Fiberscopes. A typical flexible fiberscope consists of a fiber-optic light-guide bundle, a fiber-optic image-guide bundle, an objective lens, interchangeable viewing heads, and remote controls for articulation of the distal tip. Flexible fiberscopes are available in diameters from 0.055 to 0.5 inch and in lengths of over 300 feet. The light-guide bundle is used to carry illumination from a remote source to the distal tip. Since each fiber in the light-guide bundle transmits only illumination and not an image, the fibers do not have to be precisely aligned and are generally larger than those in the image-guide bundle. The image-guide bundle is used to carry the image formed by the objective lens back to the eyepiece, and the fibers in the image guide are precisely aligned so that they are in an identical relative position to each other at their terminations for proper image resolution. The diameter of the fibers in the image guide is a factor in obtaining good image resolution. A large number of small-diameter fibers in the image-guide will provide a bright image with high resolution (see Figure 4-18). High resolution allows the use of an objective lens with a wider field of view and also allows magnification of the image at the eyepiece for better viewing of objects at the periphery of the image (see Figure 4-19). Interchangeable distal tips provide various directions and fields of view on a single fiberscope; however, because the tip can be articulated for scanning purposes, distal tips with either a forward or side viewing direction are usually sufficient. Fields of view are typically 40 to 60 degrees, although they can range from 10 to 120 degrees. Most fiberscopes provide adjustable focusing of the objective lens.

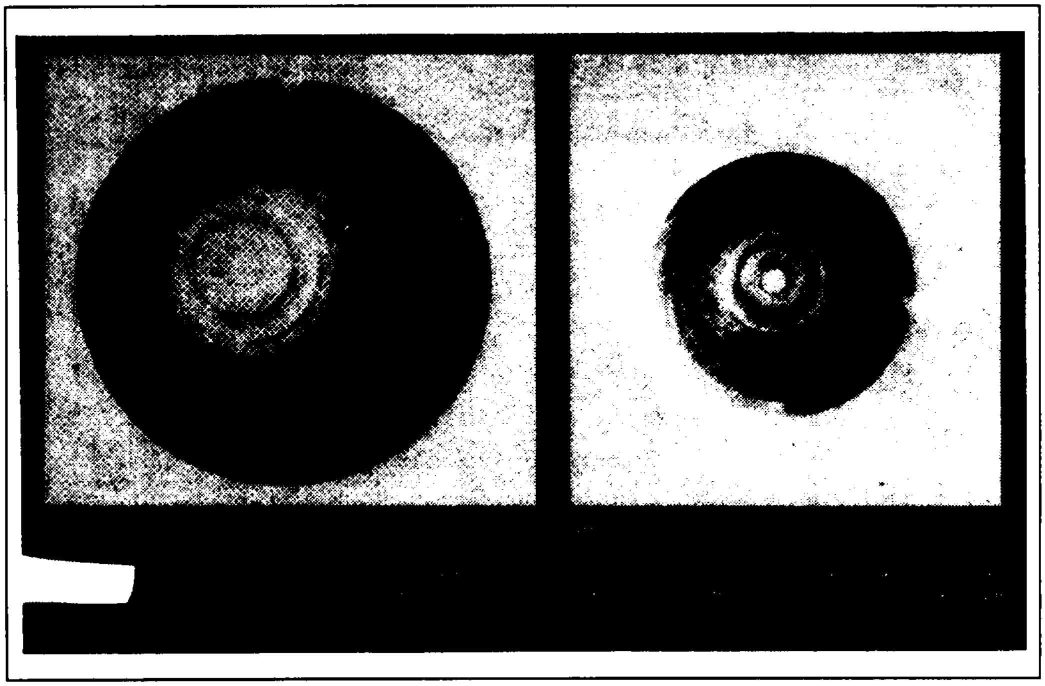


FIGURE 4-18. COMPARISON VIEWS WITH DIFFERENT QUANTITIES OF FIBERS IN THE FIBERSCOPE IMAGE BUNDLE (Courtesy of Olympus Corporation)

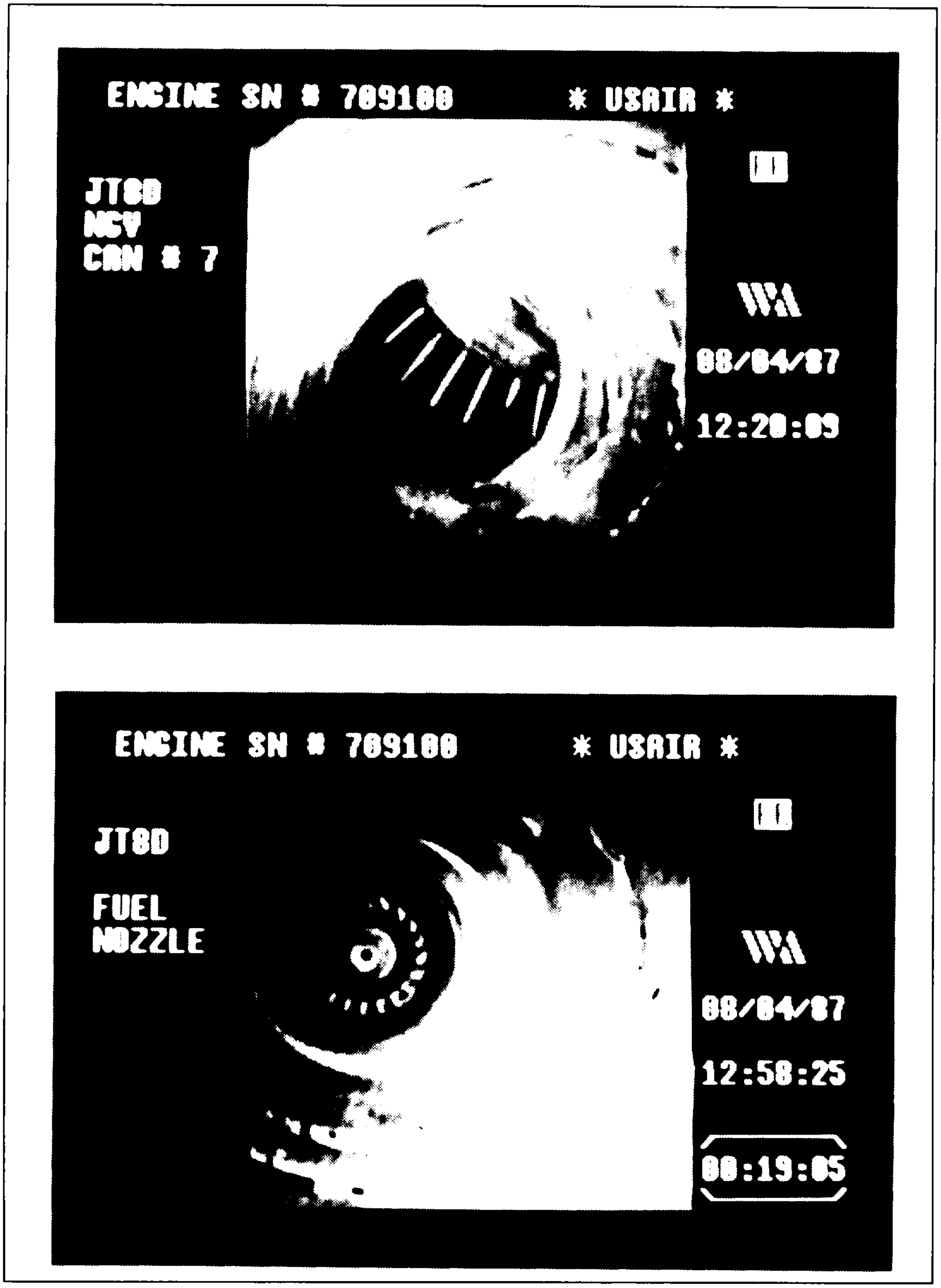


FIGURE 4-19. FLEXIBLE VIDEOSCOPE IMAGES
(Courtesy of Welch Allyn, Inc.)

(2) Flexible Videoscopes With CCD Probes. Flexible videoscopes have CCD imaging sensors at the distal tip to electronically transmit color or black and white images to a video monitor. The fiber-optic image bundle inside the insertion tube is replaced by a wire assembly to carry video information. Videoscopes with CCD imaging sensors produce images with spatial resolutions on the order of those described in Figure 4-20.

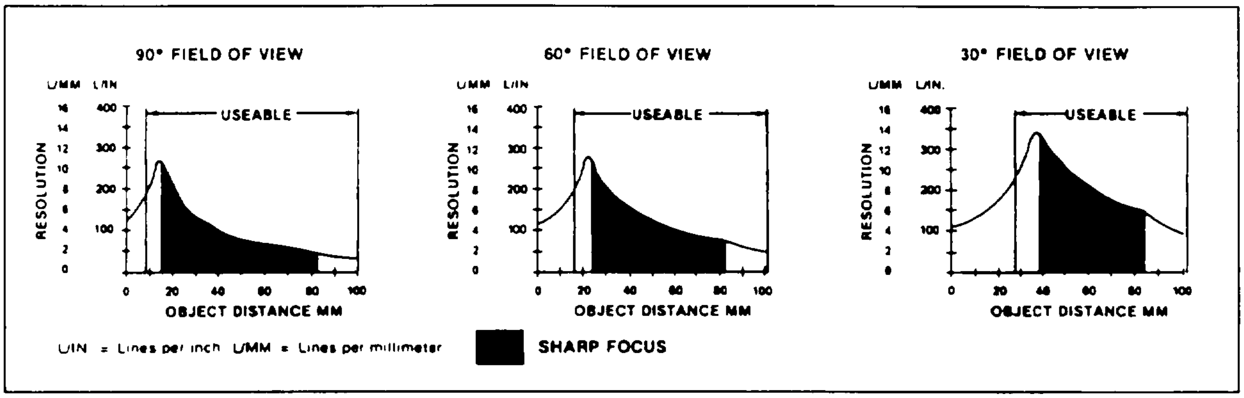


FIGURE 4-20. TYPICAL CCD VIDEOSCOPE RESOLUTION
(Courtesy of Welch Allyn, Inc.)

The resolution of videoscopes, like rigid borescopes and flexible fiberscopes, depends on the object-to-lens distance and the field of view, since these two factors affect the amount of magnification. Generally, videoscopes produce higher resolution than fiberscopes, although fiberscopes with smaller diameter fibers can be competitive with the resolution of videoscopes. A primary advantage of videoscopes is their longer working length. With a given amount of illumination at the distal tip, videoscopes can return an image over a greater length than fiberscopes. Other features of videoscopes include (1) the display can help reduce eye fatigue (but does not allow the capability of direct viewing through an eyepiece); (2) there is no honeycomb pattern or irregular picture distortion as with some fiberscopes (see Figure 4-21); (3) the electrical image signal allows digital image enhancement and the potential for integration with automatic inspection systems; and (4) the display allows the generation of reticles on the viewing screen for point-to-point measurements.

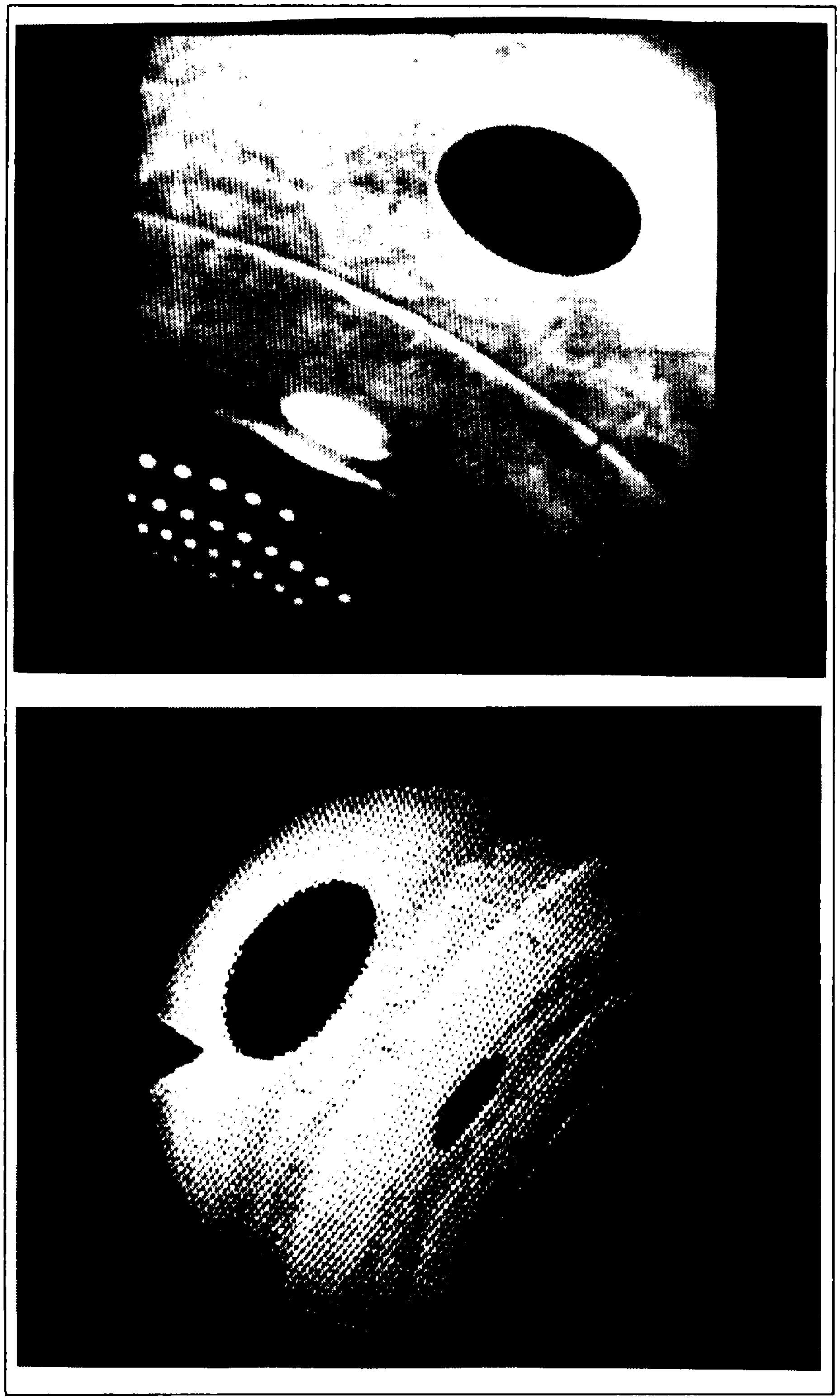


FIGURE 4-21. COMPARISON BETWEEN VIDEOSCOPE AND FIBERSCOPE IMAGES
(Courtesy of Welsh Allyn, Inc.)

f. Borescopes With Special Features. Borescopes, fiberscopes, video systems, and related equipment are being used for more purposes, more complex inspections, and even some limited repair applications. Some of the borescope products briefly described are measuring borescopes and fiberscopes, working channels, flying probe, VideoHook Probe, power blending borescope, and ShadowProbe™.

(1) Measuring Borescopes and Fiberscopes. Measuring borescopes and fiberscopes contain a moveable cursor that allows measurements during viewing (see Figure 4-22). When the object under measurement is in focus, the movable cursor provides a reference for dimensional measurements in the optical plane of the object. This capability eliminates the need to know the object-to-lens distance when determining magnification factors. Measuring borescopes and fiberscopes can be used in aircraft maintenance for measuring cracks in aircraft turbine liners, blade damage, etc.

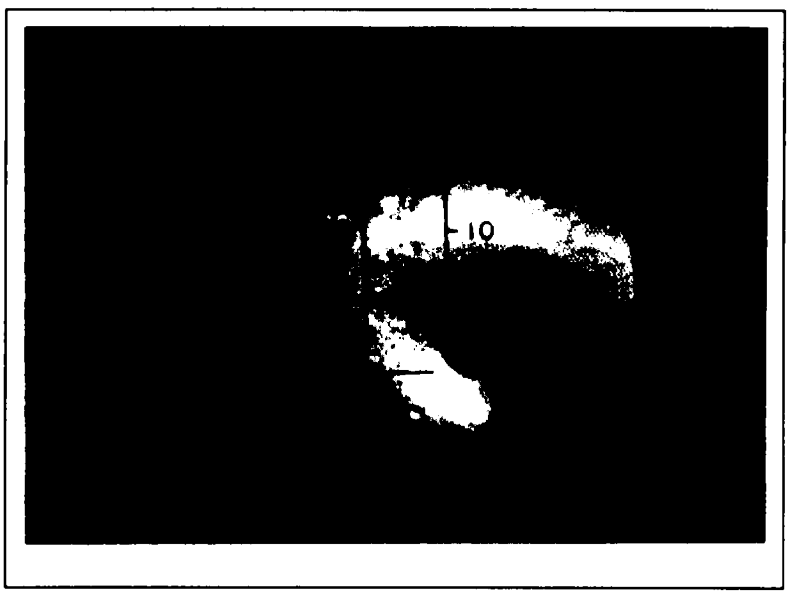


FIGURE 4-22. VIEW THROUGH A MEASURING FIBERSCOPE (Courtesy of Olympus Corporation)

(2) Working Channels. Working channels are used in borescopes and fiberscopes to pass working devices to the distal tip. Figure 4-23 shows a retrieval tool in a working channel picking up a screw inside a machine. Table 4-3 shows some typical devices for use in working channels. Working channels are presently used to pass measuring instruments, retrieval devices, and hooks for aiding the insertion of thin, flexible fiberscopes. Working channels are used in flexible fiberscopes with diameters

as small as 0.106 inch. Working channels are also under consideration for the application and removal of dye penetrants and for the passage of wires and sensors in eddy current measurements. Retrieval tools are typically used in aircraft maintenance for removing objects from aircraft turbines and appliances that may have been dropped during maintenance and repair work.

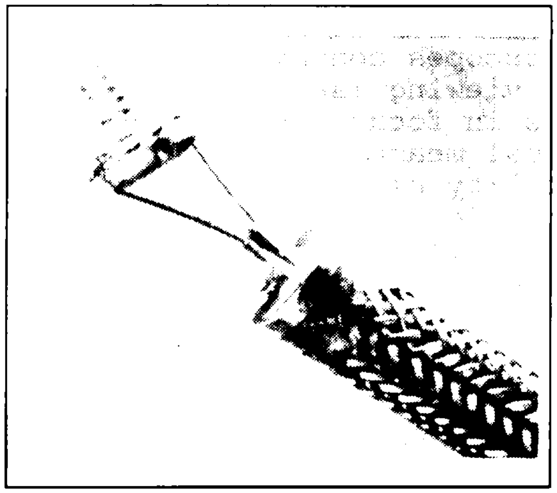


FIGURE 4-23. RETRIEVAL DEVICE IN BORESCOPE WORKING CHANNEL
(Courtesy of Olympus Corporation)

TABLE 4-3. TYPICAL WORKING CHANNEL DEVICES
(Sheet 1 of 2)
(Courtesy of Olympus Corporation)

TYPE	DIAGRAM	COMMENT
A. SAMPLING FORCEPS		
1. Standard (Fenestrated		Round jaws for normal grasping.
2. Ellipsoid (Fenestrated)		Longer jaws in order to grasp more than the standard type.
3. Alligator		Designed for scooping with side opening jaws.
4. Crescent		For lassoing foreign objects.
5. Hexagonal		For lassoing foreign objects.
6. Oval		For lassoing foreign objects.
B. GRASPING FORCEPS		
1. Tripod		Good for gripping larger solid objects
2. Hooked Jaws		Good for clenching into softer objects.
3. "W" Shaped		Collects flat foreign objects, e.g., coins.
4. Alligator Jaws		Designed to prevent slipping, grip well.
5. Rat Tooth		Jaws hinge together to provide good grip.
6. Pelican Type		Useful for awkward foreign objects.
7. Basket Type		Basket tightens up on an object for removal, e.g., ball bearings.

TABLE 4-3. TYPICAL WORKING CHANNEL DEVICES
(Sheet 2 of 2)
(Courtesy of Olympus Corporation)

B. GRASPING FORCEPS (Continued)		
8. Rubber Tipped Jaws		Good for grasping smooth surfaces.
C. MAGNETIC EXTRACTORS		
Cylindrical Shape		Good for retrieving ferromagnetic foreign objects.

(3) Flying Probe. In the so called Flying Probe, a flexible video borescope uses an air jet microthruster to help position a flexible video probe in an area to be viewed (see Figure 4-24). The air jet force can be used to pull the distal tip of the flexible video borescope through cavities to locations previously unreachable by traditional borescope techniques. The air jet microthruster system is particularly suitable for aircraft engine and structural inspections that would otherwise require the use of guide tubes.

FIGURE 4-24. FLYING PROBE FLEXIBLE BORESCOPE
(Courtesy of Welch Allyn, Inc.)

(4) VideoHook Probe. This probe consists of a special hook attachment at the distal tip of a flexible video probe (see Figure 4-25). The special hook attachment can be hooked onto the first stage turbine blade of a Pratt & Whitney JT8D series engine for more complete viewing of the second-stage, high-pressure turbine vanes. After hook attachment, the engine rotor is slowly rotated manually to allow viewing of the full second-stage vanes. The hook attachment can be slipped onto the distal tip of the

VideoHook Probe, with no special tools or working channel required, and can be easily removed when the inspection is completed. The hook is made of special soft aluminum that will reduce damage should it be left behind in the engine.

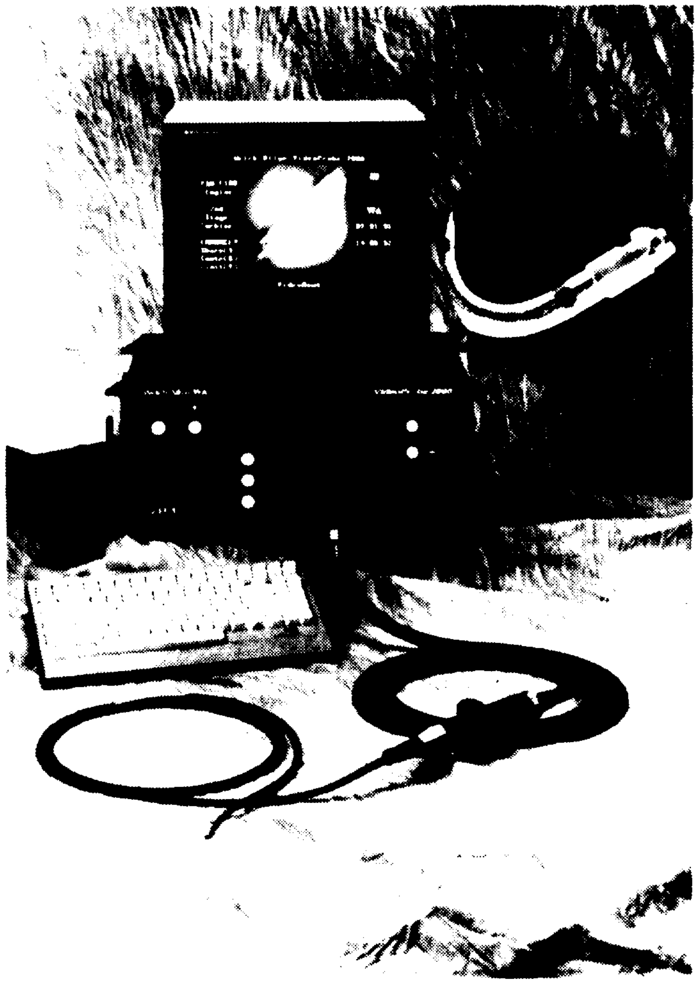


FIGURE 4-25. VIDEOHOOK PROBE ATTACHMENT FOR A FLEXIBLE BORESCOPE (Courtesy of Welch Allyn, Inc.)

(5) Power Blending Borescope Kit. A combined borescope and blending system can detect and repair (i.e., blend) foreign object damage on the 7th-stage compressor blades of JT8D-200 series engines (see Figure 4-26). The power blending borescope allows engine repair with the engine installed on the aircraft and without engine disassembly. The power blending procedure is ac-

complished with a specially designed borescope and working channel. A rotary file or stone is connected to a drive cable that passes through the working channel and a drive motor connected to this cable rotates the cutter/stone, with speed controlled by a variable-rate foot pedal. The technician operates the tool to blend damaged blades while viewing the work process on a video monitor. A video micrometer is also incorporated into the system to allow measurements to be taken.

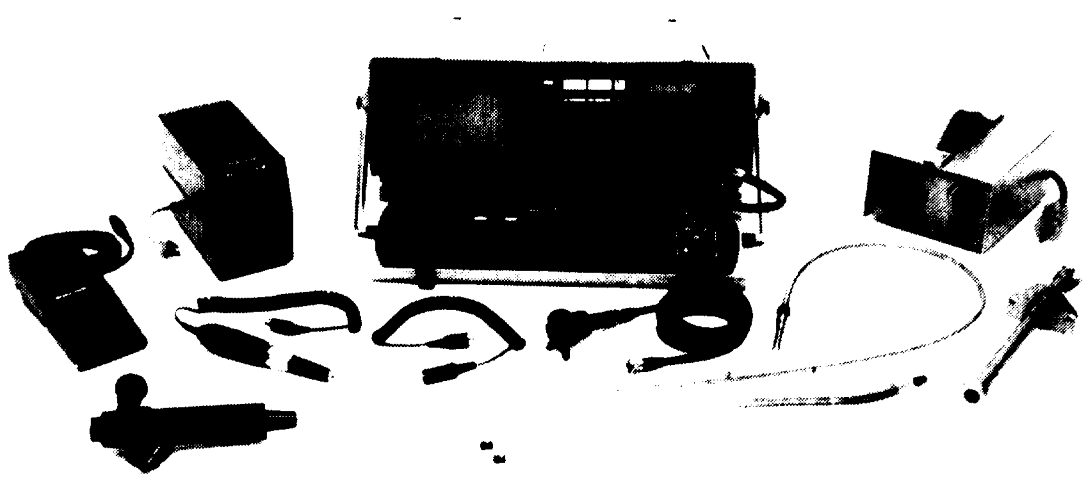


FIGURE 4-26. POWER BLENDING BORESCOPE KIT
(Courtesy of Machida, Inc.)

(6) <u>ShadowProbe™</u>. The ShadowProbe™ measuring fiberscope system measures cracks, defects, and small objects while conducting remote inspections (see Figure 4-27). The ShadowProbe™ system is designed to make measurements without comparison to reference objects by casting a shadow pattern across the system image, which is used by a system on-board computer to de-

termine magnification, distance, object size and dimensions. Operators manipulate a cursor on a video screen to locate the shadow and objects to be measured. The video screen is electronically corrected for lens distortion and has built-in automatic calibration for magnification from near or far away, over a full 85-degree viewing field. No reference point is required and there is keyboard access to three different measurement modes to allow measurement of linear distance, depth, or objects at skewed angles.

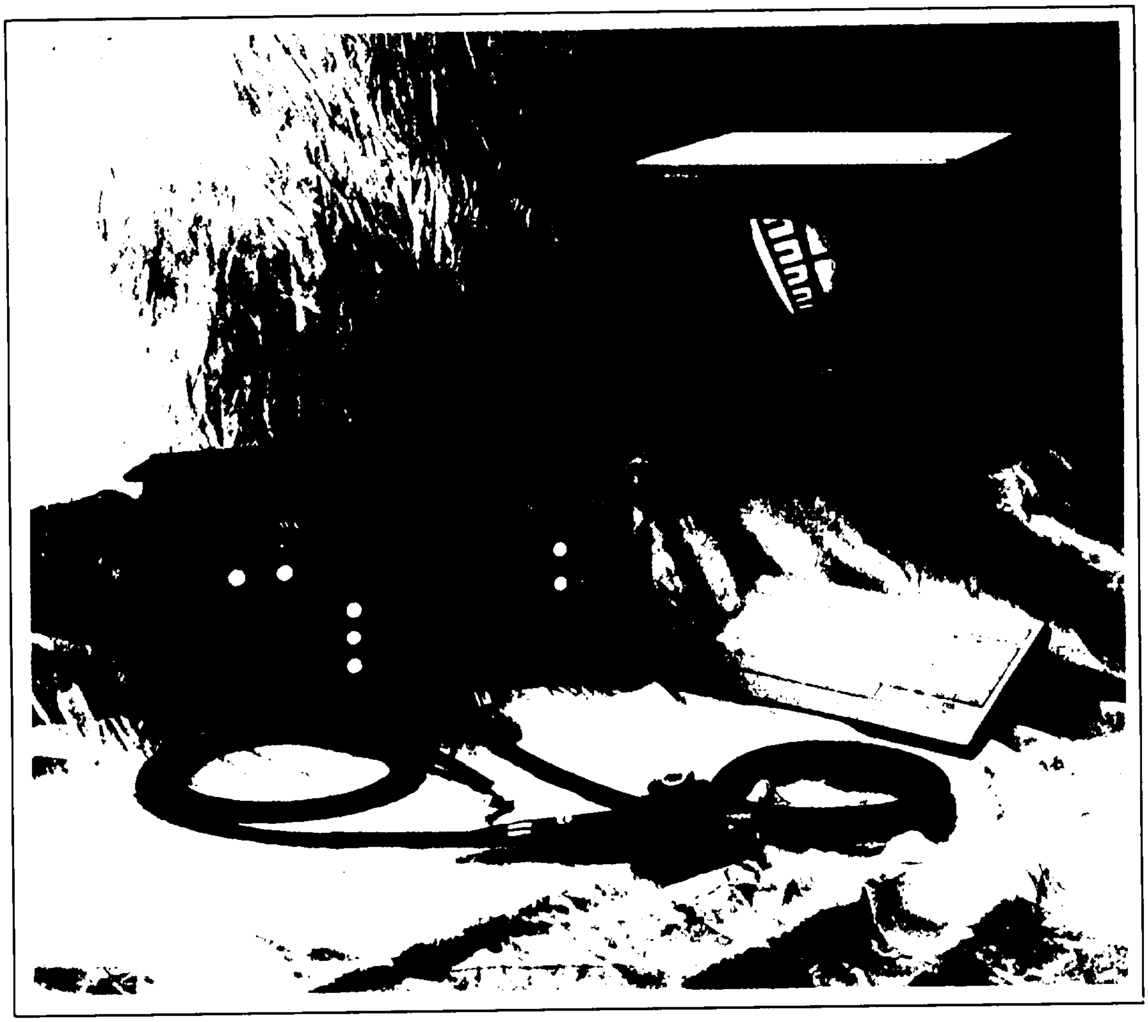


FIGURE 4-27. SHADOWPROBE™ MEASURING SYSTEM (Courtesy of Welch Allyn, Inc.)

g. Borescope Selection Questions. By answering the following questions and reviewing the information in this document and borescope manufacturers' literature, a prospective borescope user can determine which borescope offers advantages over another for a specific inspection. The answers to these questions can also be used as a guide for selecting or purchasing the most effective borescope for a particular application.

(1) Access Opening Inside Diameter (i.d.). How wide is the borescope entry point and what is the smallest i.d. that the borescope should pass through?

(2) Travel Path Geometry. Is the travel path geometry straight or curved? If a guide tube is required, what is the most severe bend the guide tube should negotiate and what is the i.d. at this point?

(3) Guide Tube. Is a guide tube needed to facilitate borescope insertion? Is it offered with the borescope? Will it have to be custom manufactured or formed on site?

(4) Borescope Length. What is the minimum length needed to travel to reach the inspection site? Is additional length needed for protection of the eyepiece or safety of the inspector using the borescope? Is a drawing available to study and lay out the access path requirements? The length of the borescope insertion probe should be well thought out, since it is related to costs and a longer insertion tube can be difficult to control in an inspection with a shallow travel path. In many circumstances, two separate borescopes for different inspections will be more economical than using one scope for multiple purposes. The probability of damage and cost of repair increases with increased borescope working length.

(5) Target Inspection Area Location. Where is the target inspection area in relation to the distal tip when the borescope reaches the target? If a flexible borescope is being considered, is there room in the work piece channel for articulating the bending section to face the target inspection area directly? How far from the target inspection area will the borescope tip be during the inspection? Will variable magnification and direction of view tip adapters be required now or later?

(6) Resolution. What is the smallest dimension needed to be seen? Can the defect be large or are microscopic defects also harmful? What will happen if a microscopic defect is missed?

(7) Frequency of Borescope Use. How often will the borescope be used? How long will the borescope be used for each inspection? How many inspections will be made for each use? How many people will use the borescope?

(8) Documentation. Will photo or video documentation of the inspection/defect be needed?

(9) Verification of Borescope Specifications. Can the borescopes specifications be verified independent of the supplier?

(10) Borescope Operation. Is an operating manual provided with the borescope that is adequate for the user's needs? Is training available to improve inspection results and reduce wear and tear on borescopes?

405. LIST OF EQUIPMENT USED IN VISUAL INSPECTION. Appendix G provides a partial listing of equipment useful in accomplishing visual inspections.

406.-499. RESERVED.

CHAPTER 5. DEFINITIONS

500. DEFINITIONS.

AC	-	Advisory Circular
AD	-	Airworthiness Directive
CRF	-	Code of Federal Regulations
CIE	-	International Commission on Illumination
MF	-	Electromotive Force
FAA	-	Federal Aviation Administration
FAR	-	Federal Aviation Regulation
HID	-	High-Intensity discharge (type of illumination)
IES	-	Illumination Engineering Society
K	-	Kelvin
MSDS	-	Material Safety Data Sheets
NFPA	-	National Fire Protection Association
NDI	-	Nondestructive Inspection
NDT	-	Nondestructive Testing
SB	-	Service Bulletin
SSID	-	Supplementary Structural Inspection Document
UL	-	Underwriters' Laboratories, Inc.

ACTIVE: Referring to the negative direction of electrode potential (opposite of noble).

ANEROBIC: An absence of oxygen in the uncombined state.

ANGSTROM (A): Unit of length usually reserved for the expression of wavelength. One angstrom equals 10^{-8} centimeter (cm). Under the standard system of units, the angstrom will be replaced by the nanometer (nm) (1.0 A = 0.10 nm). The angstrom is the standard unit for measuring wavelength of light.

ANODE: An electrode at which oxidation of the anode surface or some component of the solution is occurring (opposite of cathode).

BRIGHTNESS: The strength of sensation which results from viewing surfaces or spaces from which light comes to the eye. This sensation is determined in part by luminance (which can be measured) and in part by conditions of observation, such as the state of adaptation of the eye.

BULB: A source of electrically powered light. This term is used to distinguish between an assembled unit consisting of a light source in a housing called a "lamp" and the internal source. See LAMP.

CANDELA (cd): The metric unit of luminous intensity. One candela is one lumen per steradian (formally candle).

CATHODE: The electrode of an electrolytic cell at which reduction occurs (opposite of anode).

CELL: An electrochemical system consisting of a cathode and anode immersed in an electrolyte. The anode and cathode may be separate metals or dissimilar areas on the same metal.

CHARGE-COUPLED DEVICE (CCD): A microchip imaging sensor containing thousands of light-sensitive elements (pixels) arranged in a pattern of rows and columns. The CCD converts light from an image to electrons which, after processing, can be displayed as a picture on a video monitor.

CIE: International Commission on Illumination

CLEAN: Free of contaminants.

CONCENTRATION CELL: A cell in which potential differences at the anode and cathode are the result of differences in chemistry (concentration of reactants or products) of the environment adjacent to the electrode.

CONTAMINANTS: Any material or material residue which interferes with the visual inspection process.

CORROSION: An electrochemical deterioration of a material, usually a metal, because of a reaction with its environment. (See AC 43-4A).

CORROSION FATIGUE: A yielding of a metal resulting from the combined action of corrosion and fatigue (cyclic stressing).

CRAZING: Network of minute cracks appearing in the surface of a material.

CREVICE CORROSION: A localized corrosive attack resulting from the formation of a concentration cell in a crevice between two metal surfaces of a metal and nonmetal surface.

DEFECT: A discontinuity or group of discontinuities which do not meet specified acceptance criteria. One can have a defect within acceptable limits.

DEPOSIT: A foreign substance, which comes from the environment, adhering to a surface of a material.

DIRECT GLARE: Glare resulting from high luminances or insufficiently shielded light sources in the field of view. It is usually associated with bright areas, such as luminaires, ceilings and windows which are outside the visual task or region being viewed.

DISBOND: Areas where adhesive bonding no longer meets designed strength requirements.

DISCONTINUITY: An interruption in the normal physical structure or configuration of a part such as a crack, lap joint disbond, seam, inclusion, area of corrosion, or porosity. See DEFECT.

DUST-PROOF LUMINAIRE: A luminaire so constructed or protected that dust will not interfere with its successful operation.

DUST-TIGHT LUMINAIRE: A luminaire so constructed that dust will not enter the enclosing case.

ELECTRODE: An electrical conductor in contact with an electrolyte which serves as an electron acceptor or donor (see anode and cathode as specific examples).

ELECTROLYTE: A chemical substance or mixture, usually liquid, containing ions which migrate in an electric field.

ELECTROMOTIVE FORCE SERIES: A list of elements according to their standard electrode potentials with the value for hydrogen arbitrarily taken as 0.0 volt (also called Emf series).

EMBRITTLEMENT: A loss of load carrying capacity of a metal or alloy.

ENCLOSED AND GASKETED: See vapor-tight.

ENVIRONMENT: A description of the surroundings or conditions (physical, chemical, mechanical) in which a material exists.

EVALUATION: The review of discontinuities to determine if they meet specified acceptance criteria.

EXFOLIATION: A thick, layered growth of loose corrosion products often separating from the metal surface.

EXPLOSION-PROOF LUMINAIRE: A luminaire which is completely enclosed and capable of withstanding an explosion of a specific gas or vapor that may occur within it and preventing the ignition of a specific gas or vapor surrounding the enclosure by sparks, flashes or explosion of the gas or vapor within. It must operate at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby.

FAYING SURFACE: Interface between two adhesive surfaces.

FIELD OF VIEW: The angle in degrees that the entering light subtends at the exit pupil of the optical system. Also known as ANGLE OF FIELD.

FILIFORM CORROSION: A form of attack that occurs under films on metals and which appears as randomly distributed hairlines (also called Underfilm Corrosion).

FLAW: An imperfection in an item or material. Small flaws can be harmless. See DISCONTINUITY.

FOOTCANDLE: The unit of illuminance when the foot is taken as the unit of length. It is the illuminance on a surface one square foot in area on which there is a uniformly distributed flux of one lumen or the illuminance produced on a surface all points of which are at a distance of one foot from a directionally uniform point source of one candela.

FRETTING CORROSION: A form of deterioration caused by repetitive friction between two sliding surfaces and accelerated by a common corrosive action.

GALVANIC CELL: A corrosion cell consisting of two dissimilar metals in contact or in a narrower context consisting of adjacent anodic and cathodic sites. The former definition is on a macro-scale, the later on a micro-scale.

GALVANIC CORROSION: A type of corrosion associated with the current resulting from the coupling of dissimilar electrodes in an electrolyte.

GALVANIC SERIES: A listing of metals arranged according to their relative corrosion potentials in a specific environment (such as sea water).

GENERAL CORROSION: A type of corrosion attack uniformly distributed over a metal surface (sometimes called uniform etch corrosion).

GRAIN BOUNDARY: A narrow zone in a metal corresponding to the transition from one crystallographic orientation to another, thus separating one grain from another. The atoms in each grain are arranged in an orderly pattern.

HEAT-AFFECTED ZONE: An area adjacent to a weld where heat has caused microstructural changes which affect the corrosion behavior of the metal.

HID: High Intensity Discharge (Type of illumination)

HYDROGEN EMBRITTLEMENT: A reduction of the load carrying capability by entrance of hydrogen into the metal (e.g., during pickling or cathodic polarization).

HYDROGEN-STRESS CORROSION: A premature failure of a metal resulting from the combined action of tensile stresses and the penetration of hydrogen into the metal.

IES: Illumination Engineering Society

ILLUMINANCE: The density of the luminous flux incident on a surface; it is the quotient of the luminous flux divided by the area of the surface when the latter is uniformly illuminated. Typical units are footcandles and lumens.

ILLUMINATE: To provide, cover, or fill with light.

LUMINANCE: The luminous flux from a point divided by the area upon which it falls. See IES Handbook. (Formerly PHOTOMETRIC BRIGHTNESS.)

LUMINANCE RATIO: The ratio of the luminances of any two areas in the visual field.

MARINE ENVIRONMENT: An environment immediately adjacent to the sea coast affected by prevailing winds, fog, and other factors.

METAL: In the context of this advisory circular, a metal, metallic alloy, or material or combinations of those which exhibit metal-like properties (are electrical conductors) and are subject to corrosive attack.

NANOMETER: A unit of length equal to one billionth of a meter, or 10^{-9} meter. The nanometer has replaced the angstrom unit as a measurement of short wavelength, electromagnetic radiation.

NEWTON (N): The unit of force equal to 0.2232 lb.

NFPA: National Fire Protection Association

NOBLE: Refers to the positive direction of electrode potential, thus resembling the noble metals (such as gold).

NONDESTRUCTIVE INSPECTION: Inspection to detect internal or concealed defects in materials using techniques that do not damage or destroy the items being inspected.

OBJECTIVE LENS: The optical lens nearest the object being viewed that receives the light from the object.

PASSIVE: A condition in which the behavior of a metal is more noble (less active) than its position in the Electromotive Force Series would predict. A surface film protects the underlying metal from corrosion (opposite of active).

PASSIVITY: A phenomenon by which an active metal becomes passive.

PITTING: A very localized type of corrosion attack resulting in deep penetration at only a few sites (opposite of general corrosion).

PHOTOMETRY: The measurement of quantities associated with light.

REFLECTANCE OF A SURFACE OR MEDIUM: The ratio of the reflected flux to the incident flux.

REFLECTED GLARE: Glare resulting from reflections of high luminances from polished or glossy surfaces in the field of view. It is usually associated with reflections from within a visual task or areas in close proximity to the region being viewed (see veiling reflections).

ROOM UTILIZATION FACTOR: The quotient of the luminous flux (lumens) received on the work-plane divided by that emitted by the luminaire.

RELATIVE HUMIDITY: A ratio (percentage) of the amount of moisture in the air compared to what it could hold if saturated at a given temperature.

RESIDUAL STRESS: A stress present in a metal that is free of external forces or temperature gradients, usually the result of fabrication processes, and can be tensile or compressive in nature.

RUSTING: A type of corrosion attack limited to ferrous materials which results in reddish-brown corrosion products.

SACRIFICIAL PROTECTION: A reduction or prevention of corrosion of metal by galvanically coupling it to a more anodic metal.

SCALING: A formation at high temperature of thick corrosion product layers on a metal surface or the deposition of water insoluble constituents on a metal surface.

SEEDS: Small bubbles in glass introduced during the manufacturing process.

SMOKE, SMOKING: A haze of solid detritus (blackened aluminum compounds) caused by abrasion of a loose rivet and its surroundings.

STERADIAN (UNIT SOLID ANGLE): A solid angle subtending an area on the surface of a sphere equal to the square of the sphere radius.

STRESS-CORROSION CRACKING: A premature failure of a metal as the result of the combined action of tensile stresses and a corrosive environment. The surface tensile stresses may be residual or applied.

TARNISH: A surface discoloration of a metal caused by the formation of a thin film of corrosion product.

THRESHOLD STRESS: A limiting stress at which stress-corrosion or hydrogen-stress cracking will develop in a metal in a given exposure period.

VAPOR-TIGHT LUMINAIRE: A luminaire designed and approved for installation in damp or wet locations. It is also classified as "enclosed and gasketed."

VEILING REFLECTIONS: Regular reflections superimposed upon diffuse reflections from an object that partially or totally obscure the details to the seen by reducing the contrast (sometimes called reflected glare).

VISUAL TASK: The process of observing an object either with the aided or unaided eye and making an informed assessment of its condition.

WATTS (W): Time rate of transferring energy. Power equal to one joule per second. The following table is a conversion of light values to units of power.

Light Source*	cd/in<	kcd/m<
Clear sky	5.16	8
Candle flame (sperm)	6.45	10
60-W inside frosted bulb	77.4	120
60-W "white bulb"	19.35	30
Fluorescent lamp, cool white, T-12 bulb, medium loading	5.3	8.2
High-intensity, mercury-arc type H33, 2.5 atm	968	1,500
Clear glass neon tube, 15 mm, 60 mA	1.03	1.6

* Source; "Marks Standard Handbook For Mechanical Engineers," 9th edition, E.A. Avallone, T. Baumeister III, McGraw Hill.

501 - 599. <u>RESERVED</u>.

APPENDIX A. BEACHCRAFT, ATA CODE 57-10
SAMPLE INSPECTION PROCEDURE

Wing Front Spar-Inspection of Upper and Lower Spar Caps.

Retyped with permission of Beachcraft A Raytheon Company.

Service Instructions No. 0514-035, Rev. II

SAMPLE INSPECTION PROCEDURE

CLASS I

Beechcraft SERVICE INSTRUCTIONS

All Models Except 17, 18, 19, 23, 24, 76 and 77

No. XXXX-XXX, Rev. X
ATA Code 57-10
Recurring Inspection

Kit No. 35-4008-1 S
Kit No. 58-4002-1 S
Kit No. 100-4002-1 S
Kit No. 100-4002-3 S
Kit No. 100-4002-4 S

SUBJECT: WING FRONT SPAR - INSPECTION OF UPPER AND LOWER SPAR CAPS

SYNOPSIS OF CHANGE: Added Super King Air 200 series to inspection. Added information announcing spar replacement kits.

EFFECTIVITY: BEECHCRAFT Debonair/Bonanza 35-33 series;
Bonanza 35 series;
Bonanza 36 series;
All Model 45 (T34A), B45 and D45 (T34B) airplanes;
Twin-Bonanza 50 series,
Baron 95-55 series;
Baron 56TC series;
Baron 58 series;
Duke 60 series,
Queen Air 65 series;
Queen Air 70 series;
Queen Air 65-80 series;
Queen Air 65-88 series;
King Air 65-90 series,
Travel Air 95 series;
99 Airliner series,
King Air 100 series;
Super King Air 200 series,
that are 5 years old or older.

NOTE

Special emphasis should be placed on airplanes that have been operated

Beech Aircraft Corporation issues service information for the benefit of owners and fixed base operators in the form of three classes of Service Instructions. CLASS I (Red Border) are changes, inspections and modifications that could affect safety. The factory considers compliance mandatory. CLASS II (Green Border) covers changes, modifications, improvements or inspections the factory feels will benefit the owner and although highly recommended, they are not considered mandatory compliance unless specified at the time of issuance. Class I and II are mailed to:

(a) BEECHCRAFT Aero or Aviation Centers and International Distributors and Dealers
(b) Owners of record on the FAA Registration list and the BEECHCRAFT International Owner Notification Service List
(c) Those having a publications subscription

CLASS III (No Border) covers changes which are optional maintenance aids, product improvement kits and miscellaneous service information. Compliance is at the owner or operator's prerogative. Copies of Class III are distributed per a and c above. Information on Owner Notification Service or Subscriptions can be obtained through any BEECHCRAFT Aero or Aviation Center, International Distributor and Dealer or the Factory. As Service Instructions are issued, temporary notation in the index should be made until the index is revised. Warranty will be allowed only when specifically defined in the Service Instructions and in accordance with Beech Warranty Policy.

Service Instructions No. 0514-035, Rev. II

and/or stored for extended periods (5 years or longer) in areas where geographical location and atmospheric conditions are highly conductive to corrosion.

REASON: To inspect the upper and lower spar caps for possible corrosion.

COMPLIANCE: Within the next 100 hours time in service and at each subsequent annual inspection thereafter.

APPROVAL: FAA Approved.

MANPOWER: The following information is for planning purposes only:

Estimated man-hours for inspection: 1 hour
Suggested number of men: 1 man.

MATERIAL: If replacement of the wing main spar becomes necessary, spar installation kits are available for some models. For replacement spars on models not listed below and required installation parts not contained in the kits listed below, refer to the applicable BEECHCRAFT Parts Catalog. Kits and/or parts, if required, may be ordered through BEECHCRAFT Aero or Aviation Centers and International Distributors and Dealers. The value of the kits and/or parts, required for the incorporation of these Service Instructions on one airplane is to be advised. Prices, when issued, will be subject to change without notice. Beech Aircraft Corporation expressly reserves the right to supersede, cancel and/or declare obsolete any kits or publications that may be referenced in these Service Instructions without prior notice.

NOTICE

All BEECHCRAFT kits, unless otherwise designated, are approved for installation on BEECHCRAFT airplanes in original or BEECHCRAFT modified configurations only. BEECHCRAFT kits may not be compatible with airplanes modified by STC installation or modification other than BEECHCRAFT approved kits.

MODEL	PART NUMBER	DESCRIPTION	QUANTITY
All 35-33 through G33; all 35 through V35B; 36 and A36	35-4008-1 S	Kit, Spar Inst'l. (contains parts and information to install new fwd. wing spars. Spars are not included. Order P/N 000-110011-1(LH) or P/N 000-11001102(RH) spar assemblies.) Note: All 35 series airplanes prior to D-4866 must replace both the LH and RH spars simultaneously when installing fwd wing spars)	2 per airplane

Service Instructions No. 0514-035, Rev. II

MODEL	PART NUMBER	DESCRIPTION	QUANTITY
All 95-55 through E55, 58, 95 through E95, 56TC, 60 and A60	58-4002-1 S	Kit, Spar Inst'l. (contains parts and information to install new fwd. wing spars. Spars are not included. Order P/N 000-110011-3(LH) or P/N 000-110011-4(RH) for 95 and 55 series airplanes; order P/N 000-110011-5(H) or P/N 000-110011-6(RH) for 58 series airplanes; order P/N 000-110011-7(LH) or P/N 000-110011-8(RH) for 56TC and 60 series airplanes.)	2 per airplane
All 65, A65; 70; 65-80, 65-A80, 65-B80 thru LD-477; 65-88; 65-90, 65-A90, B90, C90 through LJ-624; E90 through LW-87; 99, 99A, A99A, B99 through U-153 that have not replaced the O.B. wing main spar per Service Instructions No. 0986 or subsequent; 100 and A100 through B-193.	100-4002-1 S	Kit, LH Spar Inst'l (contains parts and information to install new fwd. wing spars. Spars are not included. order P/N 000-110012-1(LH) or P/N 000-110012-2(RH) spar assemblies).	2 per airplane
Same as 100-4002-1 S	100-4002-3 S	Kit, LH Spar Inst'l. (same as kit P/N 100-4002-1 S except P/N 000-110012-1 spar assy. is included.)	1 per airplane
Same as 100-4002-1 S	100-4002-4 S	Kit, LH Spar Inst'l. (same as kit P/N 100-4002-1 S except P/N 000-110012-2 spar assy. is included.)	1 per airplane

WARRANTY: None.

SPECIAL TOOLS: None.

WEIGHT AND BALANCE: None.

REFERENCES: The applicable Parts Catalog for all models on which spar installation kits do not include the spars or on which spar installation kits are not available.

PUBLICATIONS AFFECTED: It is recommended that a note be made in the applicable section of all s hip manual copies to "See Service Instructions No. 0514-035, Rev. II for spar inspection procedures."

Service Instructions No. 0514-035, Rev. II

ACCOMPLISHMENT
INSTRUCTIONS: The inspection of the upper and lower spar caps may be accomplished as described in the following procedure.

1. Wash all exposed area of the upper and lower spar caps using normal cleaning procedures.

2. Visually inspect all exposed area of the upper and lower spar caps for paint blisters, raised areas and/or unevenness and cracks in the metal. Paint blisters could be caused by corrosion, therefore, if blisters are detected during the visual inspection, the area of the blister should be examined closely for unevenness and/or raised areas and cracks in the metal. The exposed area of the spar caps are extruded flat, therefore, areas of unevenness and/or raised areas on the spar caps could indicate corrosion and should be considered suspect areas. (See illustration.)

NOTE

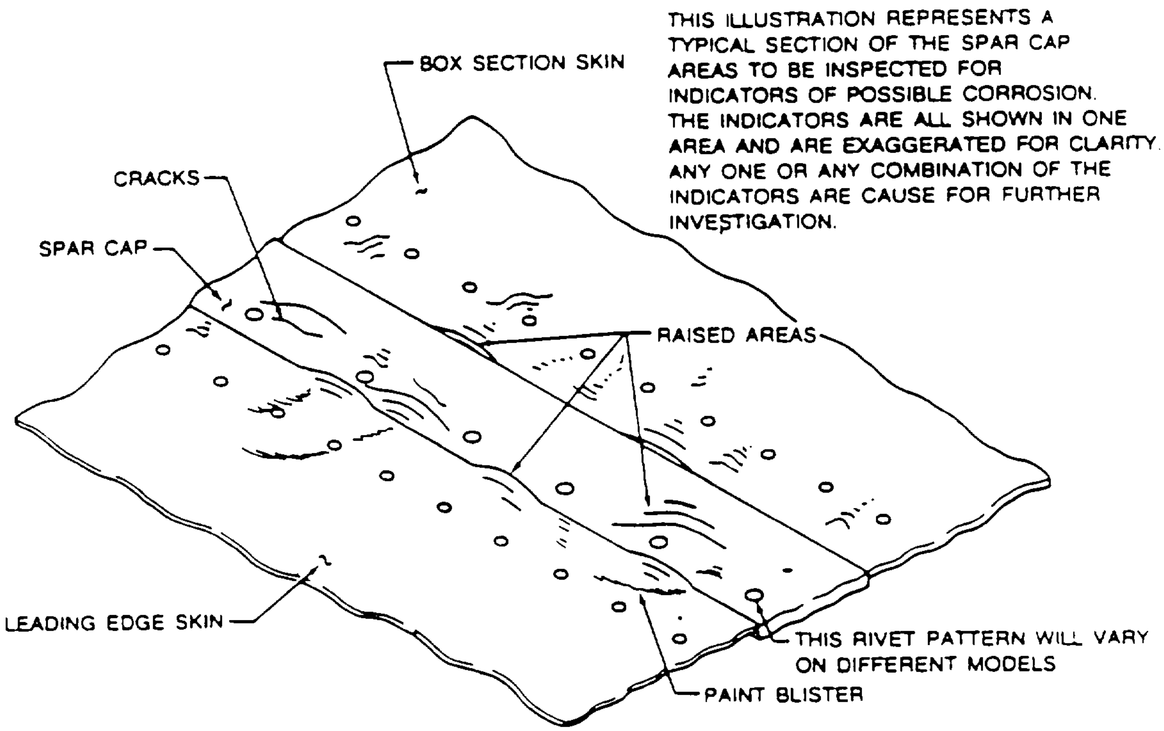
Areas of unevenness and/or raised areas on the spare caps may be detected by sliding the fingers over the surface, by moving a straightedge over the surface or by sighting down the length of the spar cap.

3. If during visual inspection, any build up of a whitish salt-like non-metallic substance is detected, the area should be examined carefully, as this is indicative of corrosion. However, wax or paint that may be trapped between the edge of the skin and the exposed section of the spar cap should not be interpreted as corrosion.

4. If unusual conditions are noted which cannot be resolved locally, advise Commercial Product Support, Beech Aircraft Corporation, Wichita, Kansas 67201.

5. For models on which spar installation kits are available, instructions for installation of the replacement spars are continued in the applicable kits.

Service Instructions No. 0514-035, Rev. II



Typical Section of the Spar Cap to be Inspected

RECORD COMPLIANCE: Upon completion of the initial and all subsequent inspections, make an appropriate maintenance record entry. When kits are installed, it is recommended that the parts list contained in the kit be filed for future reference.

APPENDIX B. BEACHCRAFT, ATA CODE 55-30
SAMPLE INSPECTION PROCEDURE

Empennage-Vertical Stabilizer - Part I, Inspection of the Vertical Stabilizer Main Spar For Fatigue Cracks and/or Nicks: Part II, Repair of Fatigue Cracks and/or Nicks in the Vertical Stabilizer Main Spar and Angle-Doubler.

Retyped with permission of Beachcraft A Raytheon Company

Service Instructions No. 0530-134, Rev. I

SAMPLE INSPECTION PROCEDURE

CLASS I

Beechcraft SERVICE INSTRUCTIONS

SUBJECT: EMPENNAGE - VERTICAL STABILIZER - PART I, INSPECTION OF THE VERTICAL STABILIZER MAIN SPAR FOR FATIGUE CRACKS AND/OR NICKS; PART II, REPAIR OF FATIGUE CRACKS AND/OR NICKS IN THE VERTICAL STABILIZER MAIN SPAR AND ANGLE-DOUBLER

SYNOPSIS OF CHANGE: Changed Part I to require removal of the vertical stabilizer for inspection and changed inspection procedures.

EFFECTIVITY: BEECHCRAFT 99, 99A, A99A and B99 Airliners, serials U-1 thru U-151 with 2000 hours or more of time in service, unless the intent of these Service Instructions has already been accomplished.

REASON: To provide procedures for inspecting the vertical stabilizer main spar and angle-doubler for possible fatigue cracks and/or nicks and repair or replacement of vertical stabilizer if cracks or nicks are found.

COMPLIANCE: PART I a. Inspection at 2000 hours of time in service.

PART I b. Inspection at intervals not to exceed 500 service hours after the initial inspection in Part I a. until the new P/N 115-640000-605 stabilizer is installed.

PART II. Repair or replace the vertical stabilizer as indicated in these Service Instructions.

NOTE

The vertical stabilizer can be replaced or the doubler repair can be made as a strengthening measure at any time if the vertical stabilizer is removed from the airplane for any reason. If the doubler repair is made following detection of a cracked spar or angle-doubler, the 500 hour inspection intervals described herein should be continued. If the doubler is installed as a strengthening measure with no evidence of cracks in the spar, of if a new vertical stabilizer is installed, inspection of the area may revert to normal routine inspection intervals.

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(a) BEECHCRAFT Aero or Aviation Centers and International Distributors and Dealers

(b) Owners of record on the FAA Registration list and the BEECHCRAFT International Owner Notification Service List

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CLASS III (No Border) covers changes which are optional, maintenance aids, product improvement kits and miscellaneous service information. Compliance is at the owner or operator's prerogative. Copies of Class III are distributed per a and c above. Information on Owner Notification Service or Subscriptions can be obtained through any BEECHCRAFT Aero or Aviation Center, International Distributor and Dealer, or the Factory. As Service Instructions are issued, temporary notation in the index should be made until the index is revised. Warranty will be allowed only when specifically defined in the Service Instructions and in accordance with Beech Warranty Policy.

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Service Instructions No. 0530-134, Rev. I

DESCRIPTION: On the initial inspection, the vertical stabilizer is to be removed from the fuselage and the main spar and angle-doubler are to be dye penetrant inspected for possible fatigue cracks. If cracks are found, the stabilizer is to be repaired or replaced as described herein. If nicks are noted in the flanges, they are to be sanded smooth as described herein. The doubler reinforcement described in Part II is to be made, or as an option, the vertical stabilizer is to be replaced regardless of the inspection results.

If the doubler repair is made following detection of a cracked spar or angle-doubler, the vertical stabilizer main spar flanges are to be visually inspected with a 3 to 5 power magnifying glass at each 500 hour interval thereafter until the vertical stabilizer has been replaced.

APPROVAL: FAA Approval - DOA CE-2.

MANPOWER: The following information is for planning purposes only.

Estimated man-hours for first inspection: 8 hours.
Suggested number of men for first inspection: 2 men.
Estimated man-hours for inspection following a doubler repair of a cracked spar: 2 hours.
Suggested number of men for inspection following a doubler repair of a cracked spar: 1 man.
Estimated man-hours for doubler installation: 16 hours.
Suggested number of men for doubler installation: 2 men.
Estimated man-hours for stabilizer replacement: 24 hours.
Suggested number of men for stabilizer replacement: 2 men.

MATERIAL: The following parts, if required, may be obtained through your BEECHCRAFT Parts and Service Outlet.

NEW P/N	OLD P/N	DESCRIPTION	QUANTITY	PRICE*
115-640000-605	115-640000-603	Vertical Stabilizer Assembly	1 per aircraft	To Be Advised
CR2249-5-5	None	Cherrylock rivet	6 per aircraft	$.38 each
CR2249-5-6	None	Cherrylock rivet	58 per aircraft	$.40 each

*Estimated suggested selling price. (Subject to change without notice.)

WARRANTY: None.

SPECIAL TOOLS: None.

WEIGHT AND BALANCE:

WEIGHT (LBS.)	ARM (INS)	MOMENT (LBS. INS)
2	431	862

REFERENCES: BEECHCRAFT 99 Airliner Series Maintenance Manual, P/N 99-590015-1 or subsequent.

Service Instructions No. 0530-134, Rev. I

PUBLICATIONS AFFECTED: It is recommended that a note to "See Service Instructions No. 0530-134, Rev. I" be made in all 99 through B99 Parts Catalog copies, P/N 99-590014D or subsequent, Figure 134.

ACCOMPLISHMENT INSTRUCTIONS: These Service Instructions may be accomplished as follows:

PART I a. FIRST INSPECTION

1. Remove the rudder and the vertical stabilizer as instructed in Chapters 27-20 and 55-30 respectively of the Maintenance Manual.

2. Drill out the rivets on both sides of the lower vertical stabilizer sufficiently to lift the skins and inspect the main spar and the angle-doubler.

3. Using dye penetrant procedures as outlined in AC43.13-1A, inspect both flanges of the main spar and the angle-doubler in the curved area just below the vertical stabilizer skin for possible cracks. Also inspect the joggle in the angle-doubler beneath the skin and just aft of the main spar flanges for possible cracks. (See Figure 1.)

4. Check the spar and angle-doubler flanges for nicks which could possible develop into cracks.

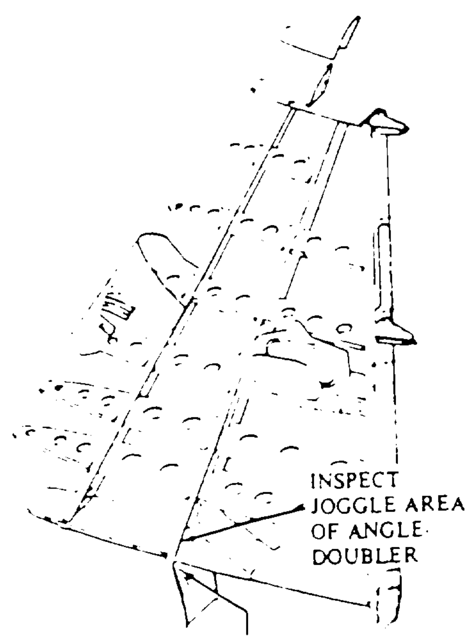

Figure 1 Vertical Stabilizer Assembly

Service Instructions No. 0530-134, Rev. I

CAUTION

If any cracks are found, contact Parts and Service Operations, Beech Aircraft Corporation, Wichita, Kansas, 67201, and report your findings for evaluation before proceeding with Part II.

PART I b. If the doubler repair is made following detection of a cracked spar or angle-doubler, the following inspection must be made at each 500 hour interval thereafter until the vertical stabilizer has been replaced.

1. Remove the tail cone.

2. Lower the front of the horizontal stabilizer to gain the greatest accessibility to the vertical stabilizer main spar where it is attached to the airplane structure.

3. Through the tail of the airplane, inspect both flanges of the main spar and the angle-doubler in the curved area just below the upper fuselage skin (Figure 1) with the aid of a 3 to 5 power magnifying glass.

NOTE

Remove the handle from the magnifying glass and fabricate a temporary handle approximately 24 inches long of wood or other suitable material. Mount the mirror on one end of the fabricated handle at an approximate 90° angle to the handle in such a manner as to hold it securely. (See Figure 2.) The long handle will facilitate the inspection through the tail opening.

4. If no new cracks or nicks are found in the main spar or the angle-doubler flanges, the tail cone may be reinstalled.

5. If new cracks of nicks are found, proceed with Part II for repair.

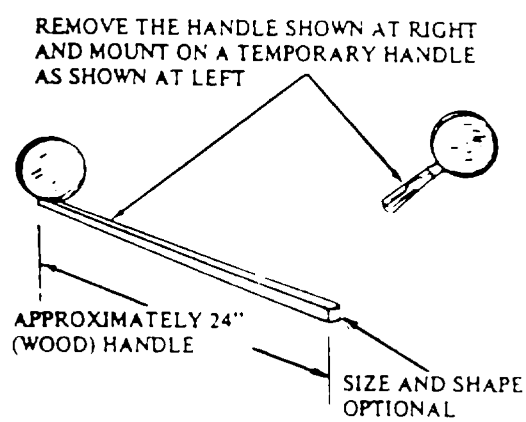

Figure 2 Inspection Magnifying Glass

Service Instructions No. 0530-134, Rev. I

PART II REPAIR

1. If nicks are found in the spar or angle-doubler flanges, they should be sanded smooth to lessen the possibility of crack development.

2. If cracks are found in either the spar flanges or in the angle-doubler flanges but not in both on the same side, to a maximum depth of .25-inch, a repair may be made to the vertical stabilizer assembly as follows.

a. Slip a stainless steel shim between the spar flange and the angle-doubler flange to prevent damage to the adjacent flange and grind out the crack. Leave a smooth edge and flair the area out to the normal flange width. (Figure 3.)

b. Fabricate and install two doublers from .125-inch by 5.0-inches by 30.0-inches and two shim spacers from .025-inch by 2.0-inches by 12.0-inches, 2024-T3 aluminum alclad, as shown in Figure 3.

c. Install one doubler and one shim on each side of the vertical stabilizer as shown in Figure 3. Reinstall the rivets which were removed in Part I for inspection of the doublers.

d. Starting from a point approximately 8-inches forward of the vertical stabilizer main spar and aft from that point, drill out all rivets which attach the vertical stabilizer/fuselage angle-fairing to the fuselage.

e. Measure the width of the doublers at the vertical stabilizer skin lower edge. (See Figure 3.) The rectangular cutout in the upper fuselage should be lengthened to at least 1.5-inches longer than the width of the doublers to allow clearance between the stabilizer and the dorsal fairing during installation of the stabilizer.

NOTE

It may be necessary to relocate the small angle at the aft of the cutout in order to achieve the necessary clearance for the doublers.

f. Reinstall the vertical stabilizer as described in Chapter 55-30 of the Maintenance Manual.

NOTE

Check the clearance between the forward surface of the main spar and the bulkhead. If the two surfaces are not flush the gap should be shimmed. (Shims may be fabricated locally from aluminum stock.)

g. Form the vertical stabilizer/fuselage angle-fairing around the doublers and reinstall the rivets which were removed in step d. Reinstall screws to attach the angle-fairing to the vertical stabilizer.

h. Reinstall and rerig the rudder and tab per Chapter 27-20 of the Maintenance Manual.

3. The preceding doubler installation is to be made on all affected airplanes (or the vertical stabilizer may be replaced with a new P/N 115-640000-605 vertical stabilizer assembly), regardless of whether cracks are noted or not with the following exception:

Service Instructions No. 0530-134, Rev. I

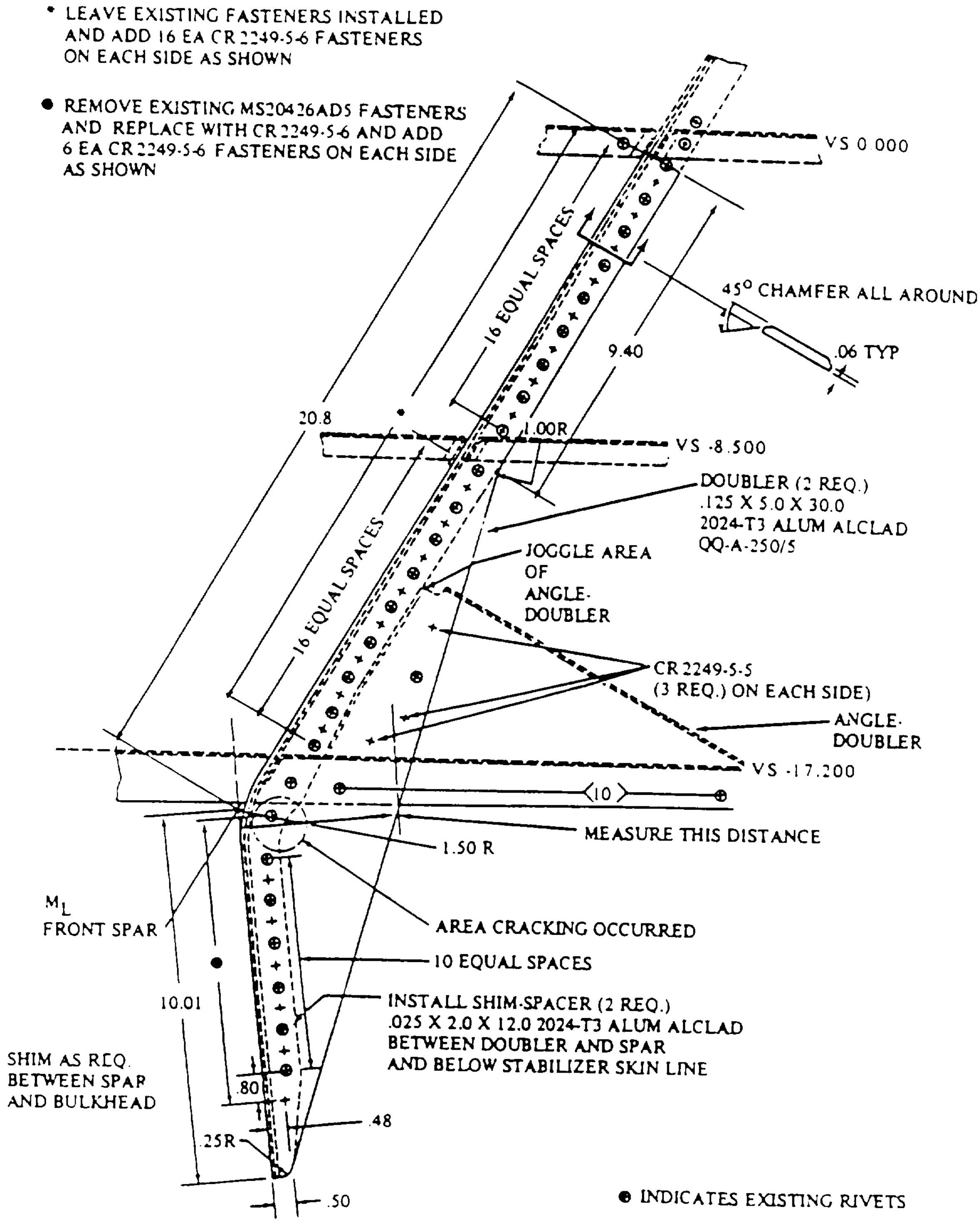

Figure 3. Fabrication and Installation of Doublers and Spacer - Shims

Service Instructions No. 0530-134, Rev. I

If cracks are found in both the spar and angle-doubler flanges on the same side and/or the cracks extend into the rivet holes or into the radius of the spar or angle-doubler, the vertical stabilizer assembly must be replaced. Removal and reinstallation of the rudder and the vertical stabilizer are described in Chapter 27-20 and 55-30 respectively of the Maintenance Manual. rerigging of the rudder and tab is described in Chapter 27-20 of the Maintenance Manual.

RECORD COMPLIANCE: Upon completion of these Service Instructions, make an appropriate maintenance record entry.

APPENDIX C. PRATT & WHITNEY ENGINE GENERAL -INSPECTION/CHECK - 00 SAMPLE INSPECTION PROCEDURE

Task 72-00-00-990-004 Paras 1-4
Task 72-31-82-990-001
Task 72-31-82-990-002
Task 72-31-82-200-003

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SAMPLE INSPECTION PROCEDURE

ENGINE GENERAL - INSPECTION/CHECK-00

Task 72-00-00-990-004

1. Preliminary Instructions

CAUTION: TITANIUM WELDMENTS AND ASSEMBLIES SHOULD NOT BE PROCESSED THROUGH TRICHLORETHYLENE DEGREASERS OR ANY CLEANER CONTAINING CHLORIDES IN ORDER TO AVOID POSSIBILITY OF STRESS CORROSION ASSOCIATED WITH ENTRAPMENT OF CHLORINE-CONTAINING MATERIALS IN TIGHT FITTING AREAS. THIS RESTRICTION ALSO APPLIES TO PARTS SUCH AS TITANIUM DISKS OR HUBS CONTAINING INSERTS, SLEEVES, OR PINS. DISKS MUST BE DEBLADED PRIOR TO CLEANING AND PRIOR TO FLUORESCENT PENETRANT OR MAGNETIC PARTICLE INSPECTION.

A. Thorough and intelligent inspection of all engine parts is one of the controlling factors in efficient and dependable maintenance, and too much emphasis cannot be placed on the importance of careful inspection and the decisions it involves. Inspection personnel must be thoroughly familiar with instructions in this chapter, in the requirements of the Standard Practices Manual and in Repair Sections.

B. After engine is disassembled and cleaned, arrange all parts of engine on inspection table so that inspector can judge the condition of engine as a whole and can readily make reference to other engine parts which may have been affected by a worn part. In this way, it will often be possible to determine at once the cause of any abnormal wear.

2. Records and Limits

A. During inspection, keep a record of the condition of all parts and a record of all fits, clearances, and spring pressures. Refer to the specific fits and clearances requirements in the appropriate Inspection/Check sections of this manual for proper limits. Attach a tag, indicating that replacement is necessary, to any part which is found to be unfit for further service. Attach a tag describing necessary refurbishment to any part which requires repair. If refurbishment will affect a fit or clearance, tag must remain with part until final assembly and must be marked with a warning to check fit or clearance.

B. When a new part is to be installed and it is important that it be identified as to engine number or position in engine; mark it by appropriate method described in Marking of Parts in Standard Practices Manual.

C. When making out inspection records or reports, use only descriptive words which accurately qualify existing conditions. In order to eliminate confusion and to maintain consistent terminology, the various physical conditions and the determination of the usual causes of wear or damage to engine parts which might be encountered during inspection are defined in the Physical Inspection Section of Standard Practices a Manual.

ENGINE GENERAL - INSPECTION/CHECK-00

Task 72-00-00-990-004:

D. If inspection reveals it necessary to replace a fitted spacer, tag spacer to indicate that replacement must be made with a part of correct classification at assembly.

3. General Inspections

A. See Standard Practices Manual as follows:
   (1) Physical Inspection
   (2) Magnetic Particle Inspection
   (3) Fluorescent Penetrant Inspection
   (4) Surface Treatments
   (5) Welding
   (6) Gage Inspection

4. Corrosion Prevention After Inspection

A. Equipment and Materials:

Item No.	Designation
P95-035	Corrosion Preventive Oil (AMS 3065)

B. After inspection, whenever it is deemed that sufficient time will elapse before reassembly to allow damage to parts from corrosion, cover all unprotected surfaces of magnesium and steel parts, or any parts with which corrosion difficulties are experienced, with Corrosion Preventive Oil (P05-035). Unless the parts are otherwise preserved for longer periods of time, they should be recoated with Corrosion Prevention Oil (P05-035), every four days.

STAGE 1 LPC BLADE ASSEMBLY - INSPECTION/CHECK-00

Task 72-31-82-990-001:

1. Inspection/Check Part Number Index - State 1 LPC Blade Assembly

A. Inspection Functional Arrangement

(1) Inspection/Check-01 through Inspection/Check-06 contain procedures for complete inspection of Stage 1 LPC blade assembly. Inspection function and applicability for this part are shown in Table 801.

INSPECTION/CHECK NUMBER	INSPECTION/CHECK CATEGORY	INSPECTION/CHECK APPLICABILITY
-0-1	Preinspection Preparation	Applicable
-0-2	Non-destructive Inspection	Applicable
-03	Visual inspection	Applicable
-04	Dimensional Inspection	Applicable
-05	Functional Check Inspection	Applicable
-06	Inspection Postrequisites	Applicable

Inspection Functional Arrangement
Table 801

B. Inspection/Check Part Number Index

(1) Table 802 is a listing of part numbers and appropriate Inspection/Check numbers. Referenced service bulletins are listed for parts introduced or obtained by service bulletin incorporation.

PART NUMBER	INSPECTION/CHECK	SERVICE BULLETIN
52A121	01,02,03,04,06	PW4ENG 72-132
53A321	01,02,03,04,06	PW4ENG 72-132

Inspection/Check Part Number Index
Table 802

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STAGE 1 LPC BLADE ASSEMBLY - INSPECTION/CHECK-01

Task 72-31-82-990-002:

1. Preinspection Preparation - Stage 1 LPC Blade Assembly

A. Prerequisites

(1) See Inspection/Check-00 (Task 72-31-82-990-001) for functional arrangement and part number applicability.

B. Equipment and Materials Required - None

C. Procedure

See Figures 801, 802 and 803.

WARNING: TO AVOID POSSIBLE INJURY TO HANDS, GLOVES SHOULD BE WORN WHEN HANDLING BLADES.

CAUTION: NICKS IN LEADING AND TRAINING EDGES BECOME INCREASINGLY CRITICAL THE CLOSER THEY ARE TO ROOT OF BLADE. THEREFORE, ANY INJURY TO THAT PORTION OF BLADE FROM PART SPAN SHROUD TO PLATFORM MUST BE TREATED WITH EXTREME CARE.

(1) Following instructions are standard inspection criteria which apply throughout inspection procedures.

(a) Blade limits are evaluated from a standpoint of structural integrity. The use of a substantial number of blades repaired to or near maximum limits, or use of blades having many repaired areas, may adversely affect compressor efficiency and therefore engine performance.

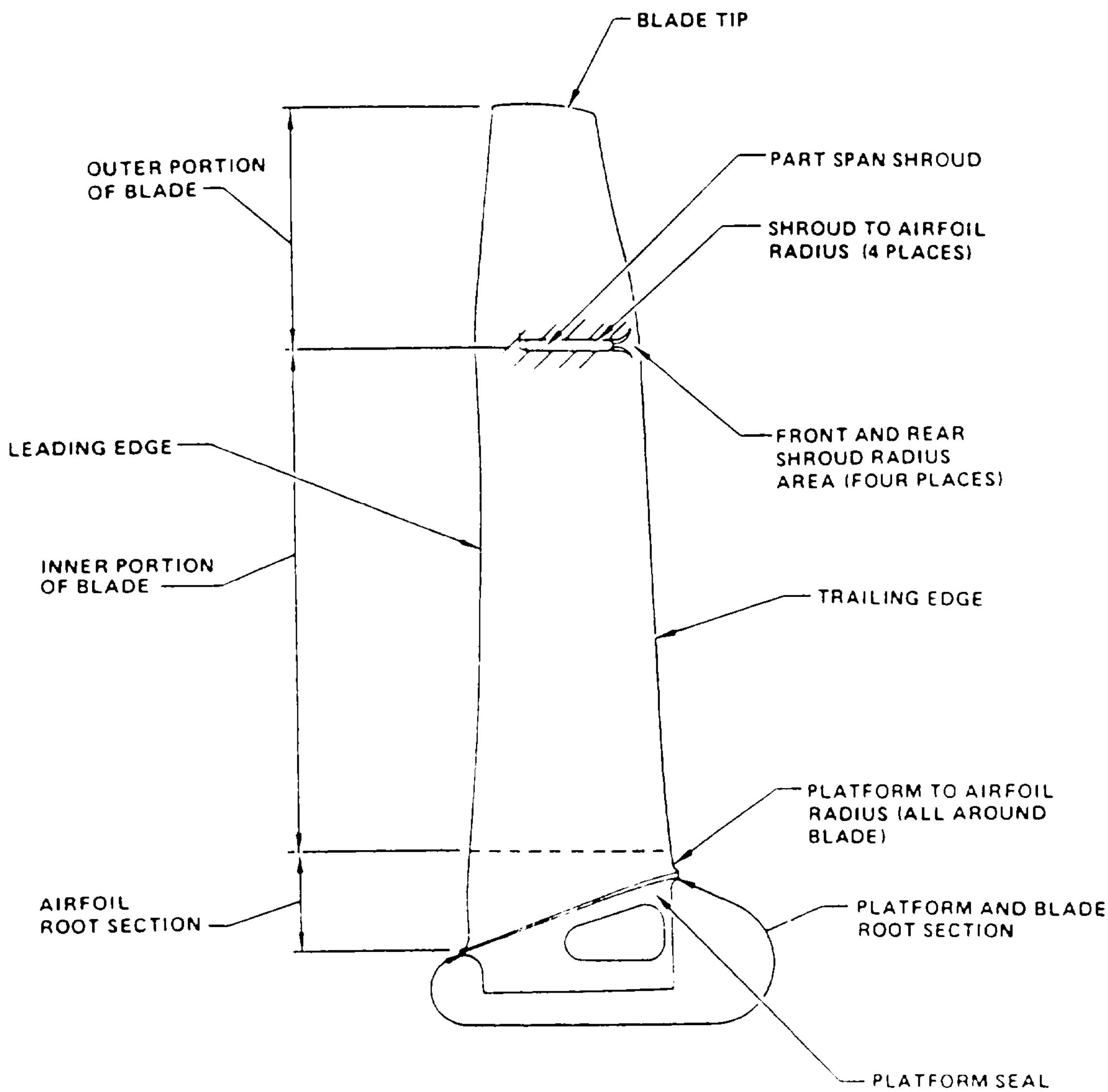
(b) All blade surfaces must be smooth and all evidence of previous leading and trailing edge repairs should be smooth with a minimum edge thickness as shown in Figure 802 maintained.

(c) All blade limits are based on original edge contour, therefore, all blends in one location are cumulative. For example, if blend depth limit is made, no further blend nor the sum of several future blends may exceed the maximum blend depth at that location. Blends directly opposite one another on leading and trailing edge are also cumulative and must not exceed maximum depth of single leading or trailing edge blend.

(d) Maximum depth blends on leading and trailing edges must be separated by minimum distance equal to mean chordal length of blade. See Figure 803

(e) Limits apply to damaged area after blending and not to magnitude of damage measured before blending.

STAGE 1 LPC BLADE ASSEMBLY - INSPECTION/CHECK-01



Blade Area Nomenclature
Figure 801
(Task 72-31-82-990-002)

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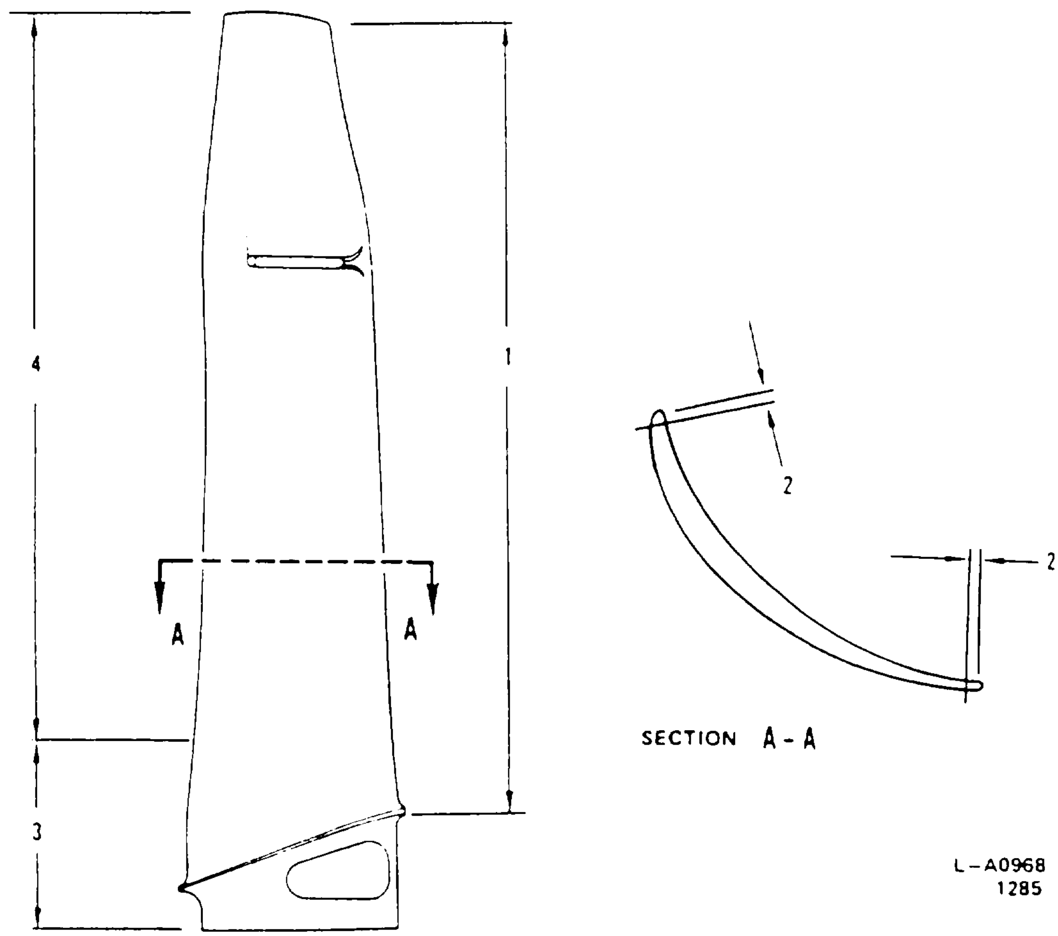
PW4000 SERIES ENGINE MANUAL (PN 50A443)

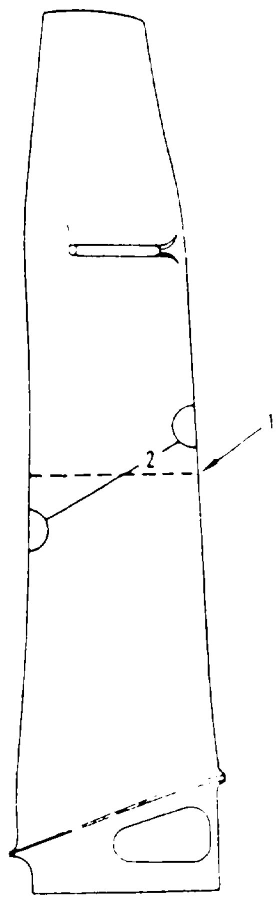
STAGE 1 LPC BLADE ASSEMBLY - INSPECTION/CHECK-01



1. Minimum Trailing Edge Thickness As Measured At Index 2 To Be 0.020 Inch (0.51 mm).
2. 0.040 Inch (1.02 mm) - Measure Leading And Trailing Edge Thickness At This Dimension.
3. 12.229 Inch (310.617 mm) - Minimum Leading Edge Thickness As Measured At Index 2 To Be 0.038 Inch (0.965 mm).
4. Minimum Leading Edge Thickness As Measured At Index 2 To Be 0.027 Inch (0.686 mm).

Leading And Trailing Edge Minimum
Thickness Limits
Figure 802
(Task 72-31-82-990-002)

STAGE 1 LPC BLADE ASSEMBLY - INSPECTION/CHECK-01



1. Mean Chordal Length Measured Equidistant Between Blends.
2. Blends Must Be separated By Minimum Dimension Equal To Index 1 Dimension

Minimum Blend Separation
Figure 803
(Task 72-31-82-990-002)

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PW4000 SERIES ENGINE MANUAL (PN 50A443)

STAGE 1 LPC BLADE ASSEMBLY - INSPECTION/CHECK-01

(f) If two or more heavily blended blades are found grouped together, an attempt should be made to redistribute these blades and their matching blades evenly throughout rotor.

(g) Total Length of leading and trailing edge blends must not exceed four inches (101.600 mm) and there must not be more than two blends to maximum depth limit per blade.

(2) Visually check leading and trailing edges of blade for damage whenever foreign object damage is suspected.

NOTE: Use of strong lights and mirrors as well as fingernails and fingertips may aid in locating damaged areas.

CAUTION: USE EXTREME CAUTION WITH ANY ELECTRICAL EQUIPMENT IN THE VICINITY OF BLADE. CONTACT WITH ANY ELECTRICAL SOURCE THAT MAY PASS CURRENT TO BLADE SURFACE CAN CAUSE AN ARC BURN. ARC BURN CAN RESULT IN LOCAL DEGRADATION OF MATERIAL PROPERTIES AND CRACK INITIATION.

(3) When checking blades for foreign object damage visually inspect for arc burn. Arc burn is evidenced by a small circular or semi-circular head affected area on blade surface that may contain shallow pitting, remelt or a crack. Blades with arc burn are not acceptable for further service.

(4) The following procedure is recommended for inspection of 1st stage blade assembly after refurbishment or repair.

(a) Visually inspect blade using a bright light, mirrors, a 3X glass, fingertips and fingernails, specifically looking for small depressions that interrupt surface contour. Refer to PWA Color Photographs for conditions that have been observed.

(b) Peening tends to remove evidence of heat discoloration and to smooth damage, making it less visually apparent.

(c) Electrical discharge damage has been observed in two different forms:

1 Strong geometric shapes such as ovals, crescents, or rectangles depressed into blade surface might be caused by contact with a rod or wire carrying an electrical charge.

2 Coarse linear indications, typically composed of small overlapping craters or pits.

NOTE: Regardless of form, damage is a local phenomenon, unlike erosion pitting, and damage boundaries do not have raised material as does damage from foreign object damage.

STAGE 1 LPC BLADE ASSEMBLY - INSPECTION/CHECK-01

(5) Blades suspected of having electrical discharge damage must be removed from service immediately, and blue etch anodize-inspected to confirm damage.

CAUTION: ELECTRICAL DISCHARGE DAMAGE IS NOT REPAIRABLE BY BLENDING. THIS DAMAGE PRODUCES A HEAT AFFECTED AREA WHICH MAY EXTEND UP TO 0.060 INCH (1.524 MM) DEEPER THAN VISIBLE DAMAGE. ANY BLADES EXHIBITING THIS DAMAGE SHOULD BE RETIRED FROM SERVICE.

(6) The blending procedures described herein are intended to ensure that all subsurface as well as surface damage is removed. It is critically important that the blending procedures be followed carefully whether performed in the shop or on the wing. Proper blending must be performed in successive stages: Removal of the visible damage, confirmation by eddy current or fluorescent penetrant inspection that all surface damage has been removed and, finally, removal of additional material to ensure the removal or subsurface deformed material.

D. Preparation For Inspection

(1) Disassemble and remove attached part(s). Not Applicable

(2) Remove surface treatments - See Repair-06 (Task 72-31-82-300-006).

(3) Clean base material - See 72-31-00, Cleaning-01 (Task 72-31-00-100-001).

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STAGE 1 LPC BLADE ASSEMBLY - INSPECTION/CHECK-03

Task 72-31-82-200-003:

1. Visual Inspection - Stage 1 LPC Blade Assembly

NOTE. Comply with the following procedures whenever foreign object damage is suspected.

A. Prerequisites

(1) See Inspection/Check-00 (Task 72-31-82-990-001) for functional arrangement and part number applicability.

(2) See Inspection/Check-01 (Task 72-31-82-990-002) for general inspection data.

B. Equipment And Materials Required - None

C. Inspect State 1 LPC Blade Assembly For Damage

See Figures 801 through 803.

(1) Inspect airfoil, except leading and trailing edges for damage. Following types of damage should be blended per repair-02 (Task 72-31-82-300-002) within limits specified in Figure 801.

NOTE: Limits shown in referenced figure refer to maximum material removal allowed during blending and not to actual depth of damage before blending. Damage at or near maximum limits shown will not be reparable if blending will exceed these limits.

(a) Sustained indentations with compressed material and raised edges.
(b) Injuries with small radii or ragged edges.
(c) Tip curl damage.

(2) Inspect leading and trailing edges for foreign object damage such as nicks and dents. These defects must be blended per Repair-02 (Task 72-31-82-300-002). See Figures 801, 802 and 803. No cracks or tears are permitted.

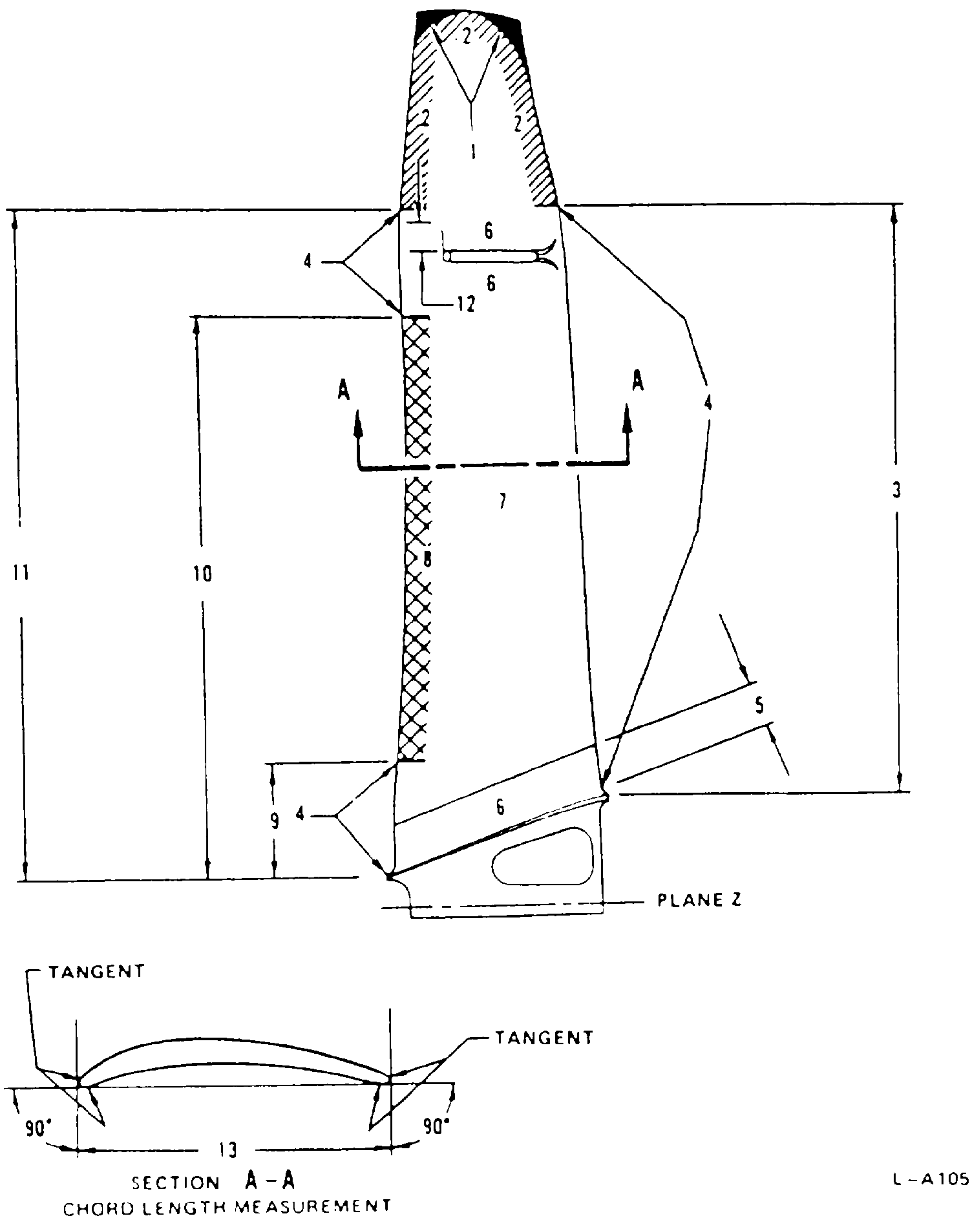
(a) Damage, not within critical area, should be blended if it exceeds 0.020 inch (0.51 mm) depth.
(b) Damage, within critical area, should be blended if it exceeds 0.005 inch (0.127 mm) in depth.
(c) Damage not exceeding 0.005 inch (0.127 mm) in depth need not be blended provided material is not torn.

D. Airfoil Root Section Blend Limits

See Figure 803.

NOTE. Amount of material removed in previous blend repairs in root section is marked on blade platform as shown in Figure 804. Amount marked is total of all repairs either to leading or trailing edge and should be a consideration when determining if damage is reparable.

STAGE 1 LPC BLADE ASSEMBLY - INSPECTION/CHECK-03



Airfoil Inspection Limits
Figure 801
(Task 72-31-82-200-003)

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STAGE 1 LPC BLADE ASSEMBLY - INSPECTION/CHECK-03

1. Blade Tip Blend Radius - 1.500 Inches (38.100 mm) Maximum.
2. Leading Or Trailing Edge And Tip Blend Area - Blend To Be 0.750 Inch (19.050 mm) Deep Maximum.
3. 19.515 Inches (495.681 mm).
4. Critical Area - Depth Of Blend To Be 0.250 Inch (6.350 mm) Maximum Except For Airfoil Root Section. See Index 5 Dimension.
5. 1.000 Inch (25.400 mm) - Damage In Airfoil-To-Platform Radius Area Cannot Be Blended Except Per Airfoil Root Section Blend Limits In Paragraph D.
6. No Damage Or Blending Permitted In Shroud-To-Airfoil Radius Or Platform-To-Airfoil Radius.
7. Concave And Convex Blade Surface Blend Area - Depth Of Blend In This Area To Be 0.030 Inch (0.762 mm) Maximum (Round Bottom).
8. Leading Edge Blend Area - Depth Of Blend To Be 0.500 Inch (12.77 mm) Maximum.
9. 6.300 Inches (160.020 mm)
10. 18.500 Inches (469.900 mm)
11. 22.500 Inches (571.800 mm)
12. 0.500 Inch (12.700 mm), Pour Places.
13. Minimum Chord Length To Be 6.950 Inches (176.530 mm) Within 6.390 Inches (160.020 mm) Of Leading Edge Platform. Chord Length Must Be Measured Tangent To Blade Leading And Trailing Edges And Parallel To Phase Z.

NOTE: Damage which affects both Index 1 and Index 2 must be blended by combining both limits to produce a smooth blend.

Key To Figure 801

APPENDIX D. PRATT & WHITNEY ENGINE GENERAL - INSPECTION/CHECK - 01A SAMPLE INSPECTION PROCEDURE

Task 72-00-00-990-009

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SAMPLE INSPECTION PROCEDURE

ENGINE GENERAL - INSPECTION/CHECK-01A

Task 72-00-00-990-009:

1. General Borescope Inspection Procedures And Borescope Access Port (AP) Data

A. Equipment And Materials Required

Special Tools:
PWA 85572-1 Compressor Rotating Kit (Foot Operated) Optional

PWA 85572-2 Compressor Rotating Kit (Hand Operated) Optional to PWA 85572-1

Special Borescope Equipment:
See Paragraph 1. C. Special Borescope Equipment.

Consumable Materials:

Item No.	Designation
P03-001	Oil, Engine (PWA 521B)
P06-003	Compound, Antigalling (PWA 586-3)

Expendable Parts:

PART NAME	QUANTITY	PARTS CATALOG REFERENCE SECTION	FIGURE	ITEM
Packing	1	72-61-00	8	160

B. General
See Figures 801 through 804 and Table 801.

Access Port	Angular Location Clockwise From Rear	Part(s) Viewable For Inspection	Recommended Maximum Probe Diameter Inch/(mm)
Thru Fan	......	1st C-Vane 1st C-Blades	....
AP-1	245° (1)	Rear of 4th C-Blade Front of 4th C-Vane	....
AP-2	233°	Rear of 5th C-Blade Front of 6th C-Blade	.270/6.8
AP-3	231°	Rear of 6th C-Blade Front of 7th C-Blade	.270/6.8

Borescope Access Port (AP) Data
Table 801

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ENGINE GENERAL - INSPECTION/CHECK-01A

Access Port	Angular Location Clockwise From Rear	Part(s) Viewable For Inspection	Recommended Maximum Probe Diameter Inch/(mm)
AP-4	127°	Rear of 8th C-Blade Front of 9th C-Blade	.270/6.8
AP-5	214°	Rear of 10th C-Blade Front of 11th C-Blade	.270/6.8
AP-6	98°	Rear of 12th C-Blade Front of 13th C-Blade	.270/6.8
AP-7	80°	Rear of 14th C-Blade Front of 15th C-Blade	.270/7.8
AP-8	277°	Fuel Nozzle Combustion Chamber 1st T-Vane	.444/11.3
AP-8	45° 128° 172° (2) 225° 338° (3)	Fuel Nozzle Combustion Chamber 1st T-Vane	.444/11.3 .444/11.3
AP-9	93°	Front of 1st T-Vane Front of 1st T-Blade	.270/6.8
AP-10	139°	Rear of 2nd T-Blade Front of 3rd T-Blade	.270/6.8
AP-11	215° (4)	Rear of 1st Turbine Blade Front of 2nd Turbine Blade	.444/11.3
Thru Exhaust Case Struts	-------	6th T-Blade 6th T-Vane	---------

NOTE: (1) Flexible probe required at this access port (optional all other ports).
(2) Right angle eye piece required at this access port.
(3) Right angle eye piece desirable at this access port.
(4) Optional borescope port location.

Borescope Access Port (AP) Data
Table 801 (Continued)

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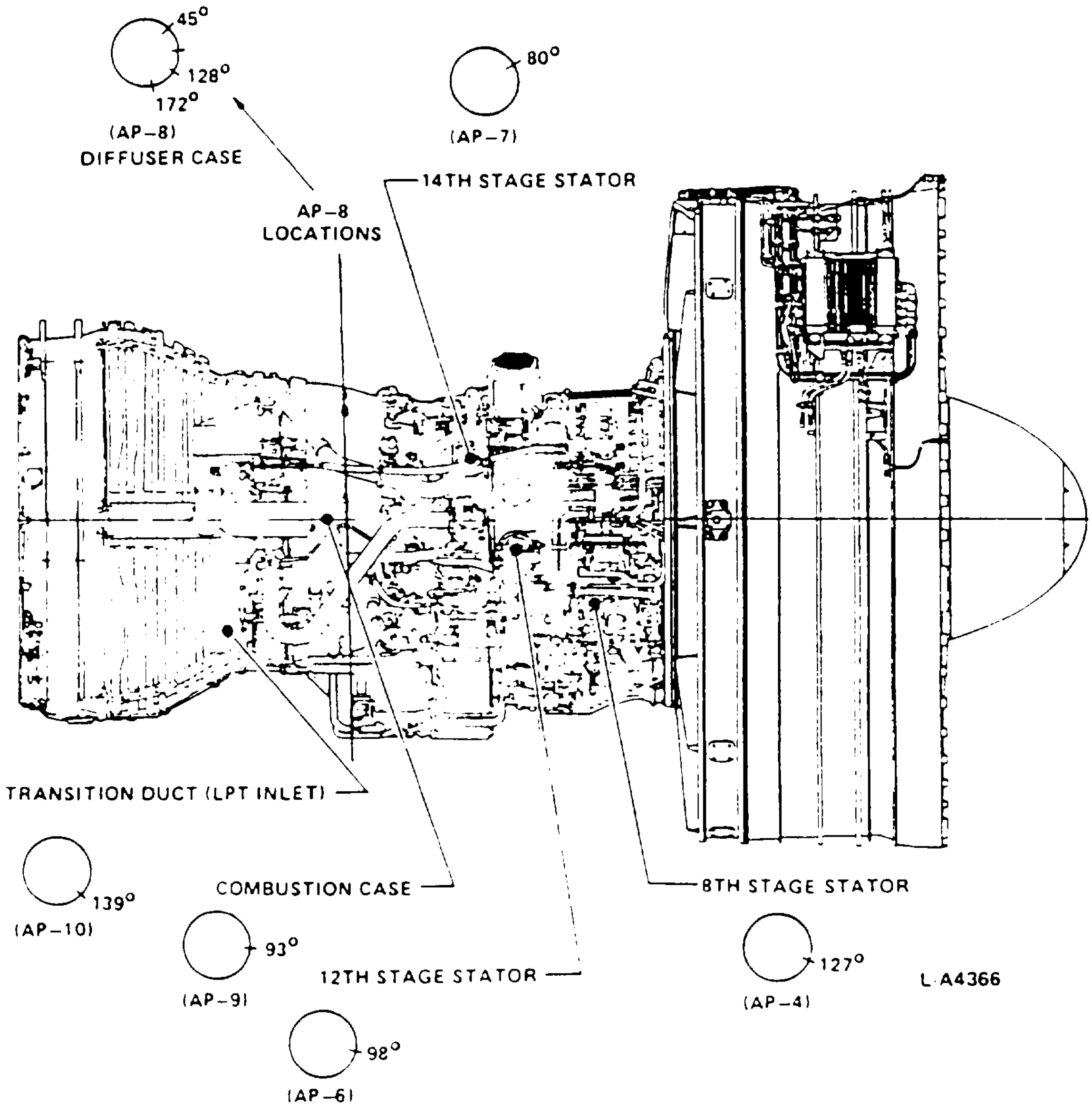
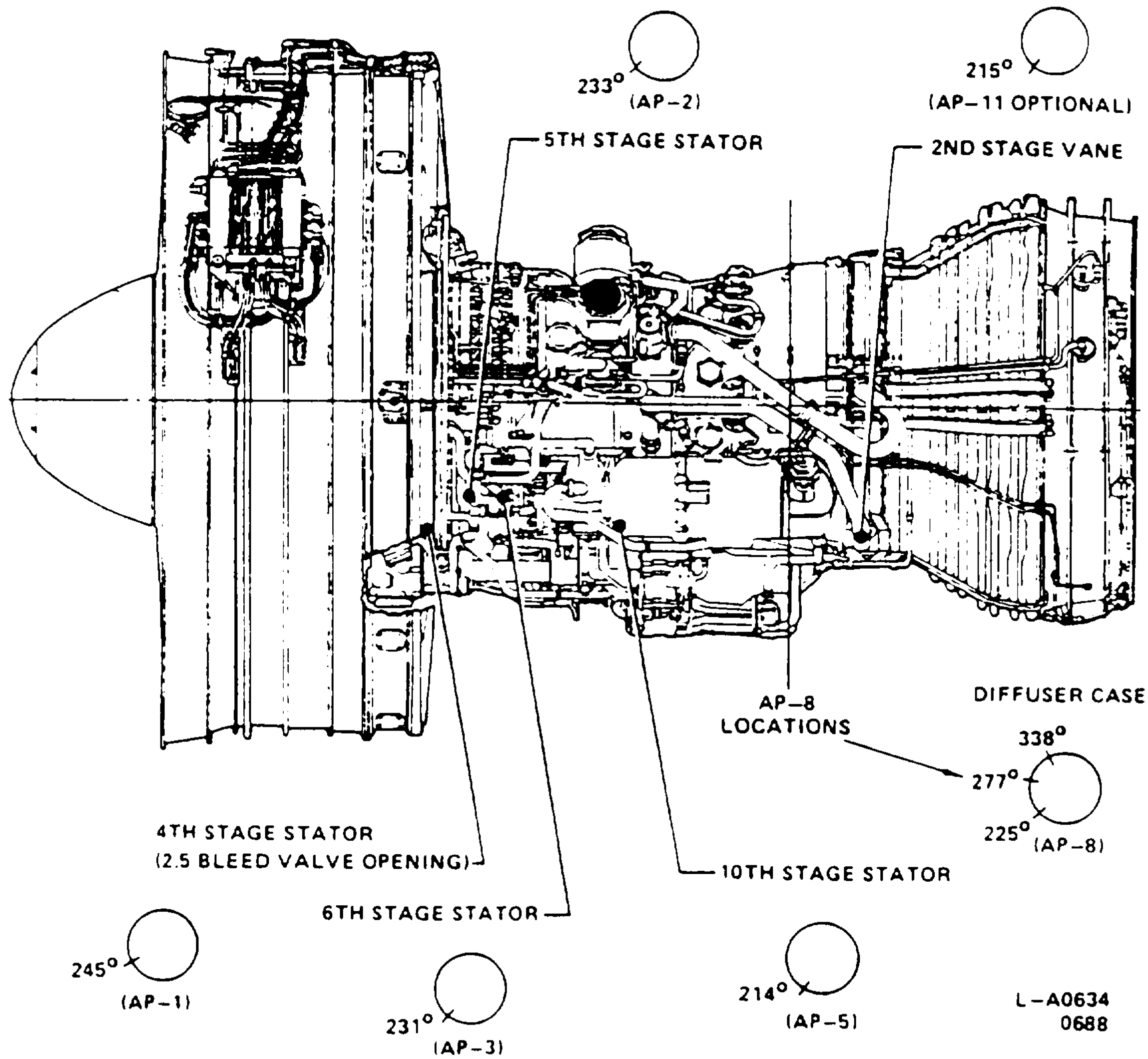
ENGINE GENERAL - INSPECTION/CHECK-01A



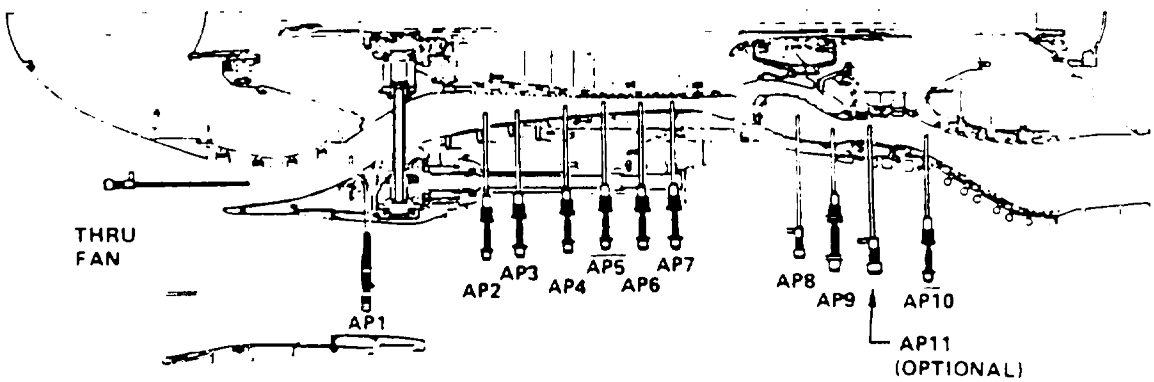
Borescope Access Ports (Right Side)
Figure 801 (Sheet 1)
(Task 72-00-00-990-009)

ENGINE GENERAL - INSPECTION/CHECK-01A



Borescope Access Ports (Right Side)
Figure 801 (Sheet 1)
(Task 72-00-00-990-009)

ENGINE GENERAL - INSPECTION/CHECK-01A



AP2–7, 9, 10 ....LOW MAGNIFICATION RIGID BORESCOPE, (.270 INCH/6.8 mm BARREL DIA. MAX.)

AP8, 11..............................HIGH MAGNIFICATION RIGID BORESCOPE, (.444 INCH/11.3 mm BARREL DIA. MAX.)

AP–1, (OPTIONAL FOR AP2–7)..............................FLEXIBLE BORESCOPE, (.270 INCH/6.8 mm CABLE DIA. MAX.)

THRU FAN (STG. 1 VANE, STG. 1.6 BLADE)......................FLEXIBLE BORESCOPE (.270 INCH/ 6.8 mm CABLE DIA. MAX.)

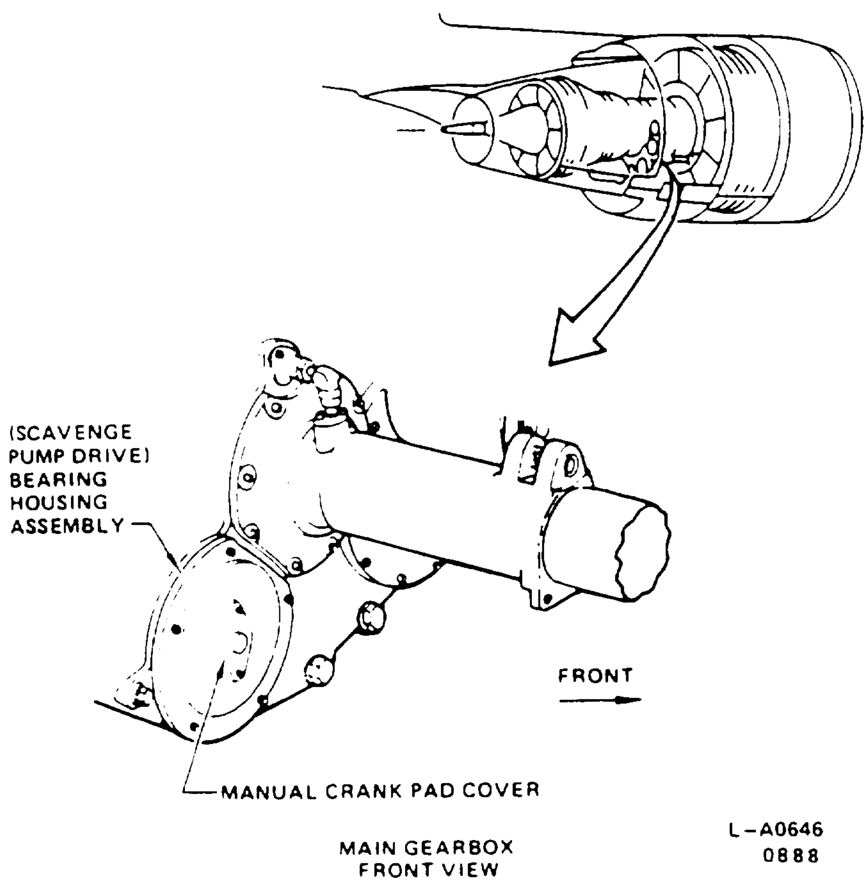
–OR–

LOW MAGNIFICATION RIGID BORESCOPE (.270 INCH/ 6.8mm BARREL DIA. MAX.)

L–A0640
0490

Borescope Access Ports (Right Side)
Figure 801 (Sheet 2)
(Task 72-00-00-990-009)

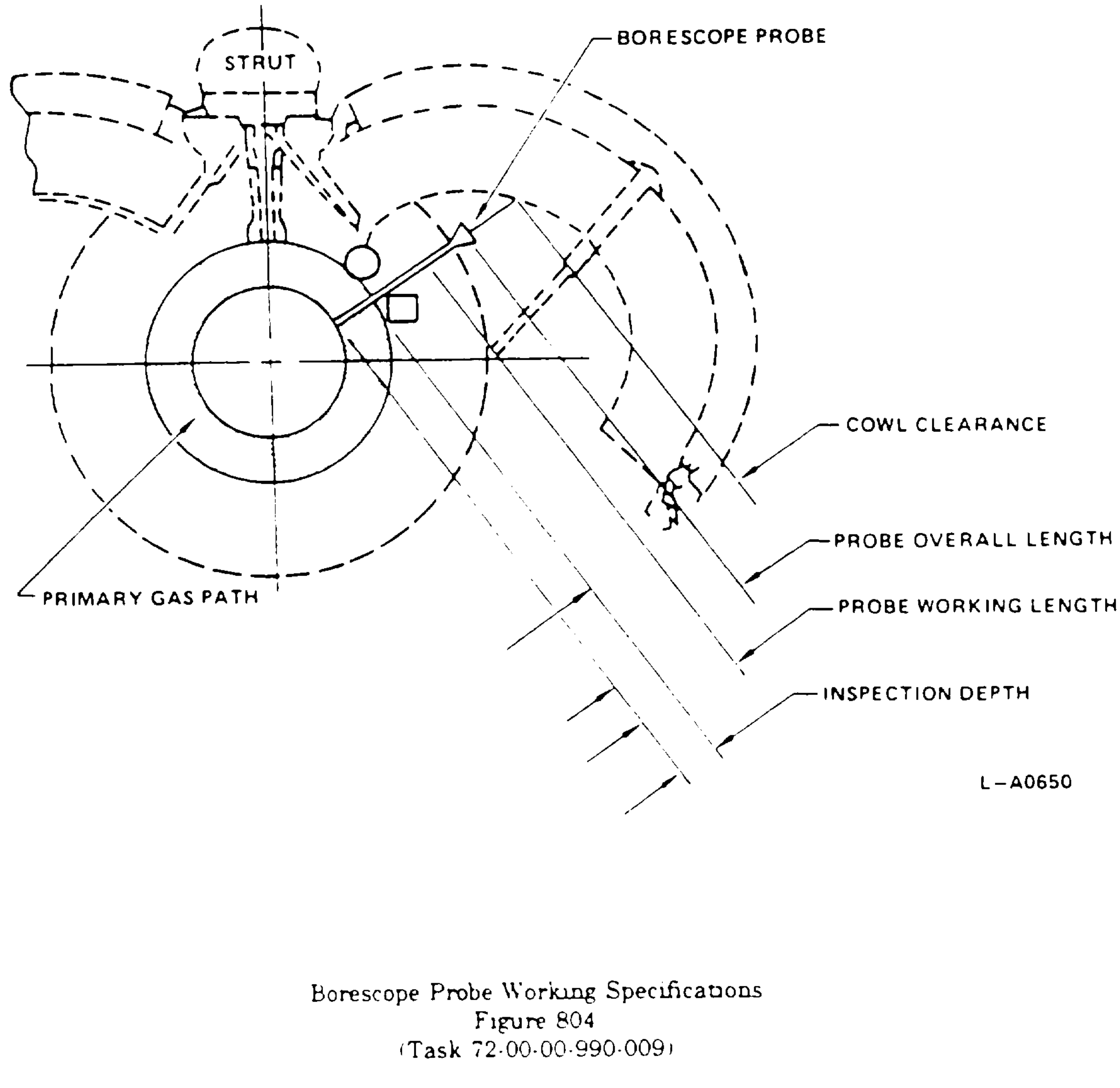
ENGINE GENERAL - INSPECTION/CHECK-01A



Manual Crank Pad Locations
Figure 803
(Task 72-00-00-990-009)

Pratt & Whitney
PW4000 SERIES ENGINE MANUAL (PN 50A443)

ENGINE GENERAL - INSPECTION/CHECK-01A



Borescope Probe Working Specifications
Figure 804
(Task 72-00-00-990-009)

ENGINE GENERAL - INSPECTION/CHECK-01A

WARNING: BORESCOPE INSPECTIONS MUST BE PERFORMED IN A PROTECTED AREA. IF INSPECTIONS ARE PERFORMED IN WET WEATHER, APPROPRIATE PROTECTION MUST BE USED TO PREVENT DAMAGE TO EQUIPMENT OR POSSIBLE ELECTRICAL SHOCK TO THE OPERATOR.

CAUTION: BORESCOPE INSPECTION LIMITS ARE DERIVED FROM TESTING AND STRUCTURAL ANALYSIS. CONTINUED SERVICE OF PARTS AT OR NEAR MAXIMUM LIMITS MAY NOT BE ECONOMICALLY SOUND BECAUSE OF PERFORMANCE LOSS OR REDUCED PART LIFE.

(1) The provisions for borescope inspection of the engine represent a significant aid to effective maintenance. Borescope access is incorporated at 15 locations (16 for engines utilizing AP-11) along the engine gaspath, allowing for detailed examination of critical internal engine areas.

NOTE: Borescope ports used in the following procedures are identified by their "AP" (access port) designation as shown in Figures 801 and 802.

(2) The regular inspection interval referred to in this procedure is obtained from the Maintenance Planning Guide. The reduced inspection interval is set at half that value. These inspection intervals may be adjusted based on operator experience and consultation with the local regulatory agency.

C. Special Borescope Equipment

CAUTION: TEMPERATURES IN AREAS TO BE BORESCOPED SHOULD BE PERMITTED TO COOL TO BELOW 150°F (65.6°C) FOLLOWING ENGINE OPERATION. DAMAGE MAY RESULT TO BORESCOPE EQUIPMENT IF EQUIPMENT IS EXPOSED TO GASPATH OR METAL TEMPERATURES IN EXCESS OF 150°F (65.6°C). AS A GUIDE - IF ADJACENT CASES ARE TOO HOT TO TOUCH COMFORTABLY, INSPECTION SHOULD BE DELAYED.

(1) Borescope inspection equipment for the PW4000 engine should satisfy the requirements of CTE 6181 as published by Support Equipment Engineering, Pratt & Whitney, Commercial Products Division, Middletown, CT 06457. U.S.A.

(2) Specification CTE 6181 identifies the equipment and associated hardware (such as power source, light cables, adapter etc.) required during borescope inspection and sets the quality and functional standards for this equipment. In summary the following borescope equipment is recommended:

(a) Low magnification rigid borescope..........AP2-7, 9
(0.270 inch/(6.8 mm) barrel diameter maximum)

(b) High magnification rigid borescope..........AP8, 11
(0.444 inch/(11.3 mm) barrel diameter maximum)

(c) Flexible borescope..........AP-1, (optional for AP2-7)
(0.270 inch/(6.8 mm) cable diameter maximum)

Pratt & Whitney
PW4000 SERIES ENGINE MANUAL (PN 50A443)

(3) Optional borescope equipment and sizes are also provided in CTE 6181 to enhance the borescoping capability and ease the task for the inspector. These items range from clamping equipment to hold the borescope in position to optical video equipment to view and videotape record the borescoping session for later in depth review.

D. Rotation Of High Pressure Rotor During Borescope Inspection
See Figure 803.

(1) Full 360 degree borescope inspection of the high pressure rotor can be accomplished using the rotor-cranking provision on the gearbox.

(2) Remove manual crank pad cover (Figure 803) on main gearbox.

CAUTION: DO NOT REMOVE THE GEARBOX (SCAVENGE PUMP DRIVE) BEARING HOUSING ASSEMBLY. INSTALLATION OF THE BEARING HOUSING ASSEMBLY IS DIFFICULT. INCORRECT INSTALLATION WILL DAMAGE THE BEARING.

(a) Remove two bolts and two washers securing manual crank pad cover. Using PWA 85768 Puller, remove crank pad cover. Discard packing from stem of cover.

(b) Attach PWA 85572-1 Foot Operated Rotator or PWA 85572-2 Hand Operated Rotator to N2 rotator pad. Make sure socket drive in the angle drive adapter aligns correctly with hex end of oil pump idler gear in gearbox and secure using two 1/4 - 28 cap screws provided. Attach an air supply to the pneumatic motor. Actuate using foot or hand control.

NOTE: Use of motor-drive unit will free operator to use both hands to position and adjust the borescope. It is recommended that rotation be stopped as each rotor blade is positioned properly for inspection. This will allow thorough, detailed appraisal of each blade's condition.

(3) Install manual crank pad cover.

(a) Install packing lubricated with Engine Oil (P03-001), in groove on stem of manual crank pad cover. Install cover and secure with two washers and two bolts lubricated with Antigalling Compound (P06-003). Torque bolts to 62 - 72 lb-in. (7.005 - 8.135 N.m).

APPENDIX E. DC-9 SERVICE BULLETIN SAMPLE INSPECTION PROCEDURE

Excerpts of Douglas Aircraft Company McDonnell Douglas DC-9 Service Bulletin Alert. Bulletin A53-232, March 28/90.

Retyped with permission of Douglas Aircraft Company McDonnell Douglas

SAMPLE VISUAL INSPECTION PROCEDURE

DOUGLAS AIRCRAFT COMPANY
MCDONNELL DOUGLAS

ALERT

BULLETIN

DC-9

P O Box 1771
Long Beach, CA
90801

SERVICE BULLETIN

FUSELAGE - Main Frame - Inspect/Repair Aft Fuselage Ventral Pressure Bulkhead Tee.

SUMMARY

This Alert Service Bulletin is affected by Federal Aviation Administration Airworthiness Directive No. 89-16-12: Amendment 39-6287, effective September 7, 1989.

This Alert Service Bulletin is applicable only to aircraft equipped with ventral aft pressure bulkhead which have accumulated 35,000 or more landings.

Replacement of all six aft pressure bulkhead tee sections with new improved parts per this Alert Service Bulletin constitutes closing action for the repetitive inspection requirements of this Alert Service Bulletin.

This Alert Service Bulletin supersedes but does not cancel the requirements of DC-9 Alert Service Bulletin XX.XXX. Only aircraft listed in this Alert Service Bulletin that are contained in the Affectivity of Alert Service Bulletin XX-XXX are affected by this contingency.

This Alert Service Bulletin is issued as a partial record-type change. A service rework drawing or aperture cards are furnished in lieu of illustrations.

1. Planning Information:

   A. Affectivity:

      (1) Aircraft Affected:

         DC-9, Series 10, 20, 30, 40, 50, and C-9,
         DC-9-81, -82, and -83 (MD-81, -82, and -83)

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SAMPLE VISUAL INSPECTION PROCEDURE

FUS	(FSN)	FUS	(FSN)	FUS	(FSN)	FUS	(FSN)	FUS	(FSN)	FUS	(FSN)
1160	(49257)	1185	(49265)	1210	(49291)	1235	(49236)	1260	(49415)	1285	(49394)
1161	(49258)	1186	(49250)	1211	(49292)	1236	(49383)	1261	(49402)	1286	(49395)
1162	(49259)	1187	(49288)	1212	(49293)	1237	(49384)	1262	(49216)	1287	(49386)
1163	(49263)	1188	(49206)	1213	(49294)	1238	(49266)	1263	(49421)	1288	(49387)
1164	(49269)	1189	(49207)	1214	(49295)	1239	(49267)	1264	(49422)	1289	(49324)
1165	(49270)	1190	(49208)	1215	(49296)	1240	(49425)	1265	(49318)	1290	(49352)
1166	(49271)	1191	(49209)	1216	(49297)	1241	(49428)	1266	(49319)	1291	(49443)
1167	(49272)	1192	(49210)	1217	(49298)	1242	(49429)	1267	(49320)	1292	(49501)
1168	(49273)	1193	(49289)	1218	(49299)	1243	(49213)	1268	(49217)	1293	(49478)
1169	(49252)	1194	(49280)	1219	(49300)	1244	(49385)	1269	(49390)	1294	(49358)
1170	(49202)	1195	(49290)	1220	(49301)	1245	(49214)	1270	(49391)	1295	(49326)
1171	(49264)	1196	(49366)	1221	(49302)	1246	(49309)	1271	(49416)	1296	(49327)
1172	(49188)	1197	(49367)	1222	(49303)	1247	(49310)	1272	(49392)	1297	(49479)
1173	(49189)	1198	(49368)	1223	(49304)	1248	(49311)	1273	(49321)	1298	(49480)
1174	(49203)	1199	(49369)	1224	(49355)	1249	(49312)	1274	(49218)	1299	(49283)
1175	(49286)	1200	(49281)	1225	(49380)	1250	(49356)	1275	(49363)	1300	(49502)
1176	(49287)	1201	(49373)	1226	(49305)	1251	(49357)	1276	(49364)	1301	(49328)
1177	(49231)	1202	(49211)	1227	(49306)	1252	(49372)	1277	(49365)	1302	(49329)
1178	(49232)	1203	(49233)	1228	(49307)	1253	(49215)	1278	(49417)	1303	(49436)
1179	(49204)	1204	(49234)	1229	(49308)	1254	(49420)	1279	(49393)	1304	(49440)
1180	(49190)	1205	(49379)	1230	(49279)	1255	(49313)	1280	(49322)	1305	(49396)
1181	(49277)	1206	(49370)	1231	(49381)	1256	(49314)	1281	(49323)	1306	(49331)
1182	(49164)	1207	(49371)	1232	(49382)	1257	(49315)	1282	(49282)	1307	(49332)
1183	(49278)	1208	(49374)	1233	(49212)	1258	(49316)	1283	(49423)	1308	(49481)
1184	(49205)	1209	(49284)	1234	(49235)	1259	(49317)	1284	(49424)	1309	(49482)

(a) Operator and Aircraft Number:

This modification will be incorporated prior to delivery on all applicable DC-9, Series MD-80; MD-88 aircraft, manufacturer's fuselage number 1310 and subsequent.

(2) Spares Affected:

None:

B. Reason:

Eight operators have reported cracks in the ventral aft pressure bulkhead attach tee sections on eight aircraft. The affected aircraft had accumulated between 45,492 and 60,969 landings when the cracks were found. The predominant areas of cracks are at the upper pylon attach angle between longerons 13 and 14 (6 cases) and lower pylon attach angle between longerons 16 and 17 (2 cases). Longerons 2, 7, 11, and 18 each had one crack. The cracks exhibited similar behavior, cracking circumferentially approximately 1.9 inches outboard of the inboard edge of the upstanding leg of the bulkhead attach tee sections. Cracks were found up to 8.8 inches in length. Analysis of failed parts revealed that the cracks initiated at multiple sites on the forward surface of the upstanding leg of the tee as the result of fatigue due primarily to bending loads. If cracks are not detected and repaired, they could progress to the point

SAMPLE VISUAL INSPECTION PROCEDURE

that rapid decompression could occur. Inspection of high cycle aircraft and accomplishment of repairs based on condition will allow continued flight operation.

C. Description:

This Service Bulletin accomplishes the following on the fuselage aft pressure bulkhead.

Inspection from Aft Side of Bulkhead

Performs visual inspections for cracked aft pressure bulkhead web-to-fuselage tee sections around entire periphery of the fuselage from aft side of bulkhead and accomplishes the following:

Condition 1 (No Crack)

Repetitively visually inspects for cracks from aft side of bulkhead at intervals specified in Compliance paragraph.

Condition 2 (Crack)

Replaces cracked tee section with new or improved part and repetitively visually and for cracks from aft side of bulkhead at intervals specified in Compliance paragraph.

D. Compliance:

It is recommended that initial inspection/repair of aft pressure bulkhead tee be accomplished as follows on aircraft having logged over 35,000 landings.

Accumulated Landings	Initial Inspection
35,000 to 49,999	Within 1500 landings from issue date of this Service Bulletin.
50,000 to 59,999	Within 100 landings from issue date of this Service Bulletin.
60,000 and over	Within 300 landings from issue date of this Service Bulletin.

When aft pressure bulkhead tee section is replaced with new like part, the repetitive inspection for that section of tee may be discontinued until the aircraft has accumulated an additional 35,000 landings at which time the repetitive inspection for that section of tee are reinstated along with the ongoing repetitive inspections of the remaining original sections of tee.

When aft pressure bulkhead tee section is replaced with new improved part per this Service Bulletin, the repetitive inspection for that section of tee may be discontinued as this constitutes closing action for that section of tee. Perform the recommended repetitive inspections on the remaining original tee sections.

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SAMPLE VISUAL INSPECTION PROCEDURE

Replacement of all six aft pressure bulkhead tee sections with new improved parts per this Alert Service Bulletin constitutes closing action for the inspection requirements of this Alert Service Bulletin.

It is recommended that repetitive inspection/repair of aft pressure bulkhead tee be accomplished as follows:

Inspection from Aft Side of Bulkhead

It is recommended that repetitive visual inspection of top and lower areas from longeron 7 left side to longeron 7 right side, and lower fuselage longeron 17 to longeron 20 on fuselage left and right sides, be accomplished at intervals not to exceed 1500 landings.

It is recommended that repetitive visual inspection for cracks of bottom areas from longeron 20 left side to longeron 20 right side, be accomplished at intervals not to exceed 3500 landings.

It is recommended that cracked tee section be replaced prior to further pressurized flight.

E. Approval:

The resultant modification described in paragraph 1.C has been shown to comply with the applicable Federal Aviation Regulations and is approved by the Manager, Los Angeles Aircraft Certification Office, FAA Northwest Mountain Region, on February 13, 1990 and is approved as an alternate means of compliance with paragraphs A and B of Airworthiness Directive 89-16-12.

F. Manpower:

NOTE: Man-hours are estimated based on work to be performed by skilled personnel on aircraft/unit which has ben placed in a maintenance status. The man-hour/elapsed time estimates do not include:

1. Preparation for the modification: Examples; defueling, purging, placing work stands, opening standard access doors, obtaining tools, and jacking when not essential to the modification.

2. Nonproductive elapsed time: Examples; sealant or adhesive cure time, cleaning, paint drying time, lunch and/or rest periods, and quality assurance inspections.

SAMPLE VISUAL INSPECTION PROCEDURE

3. Administrative functions: Examples: planning, engineering liaison, parts requisition, shift change coordination, and report writing.

Operations should take the above into consideration when scheduling this modification.

Inspection from Aft Side of Bulkhead

Optically aided visual inspection from the aft side of the fuselage aft pressure bulkhead may be accomplished in approximately 22.0 man-hours or 11.0 elapsed hours per aircraft.

Man-hours do not include time for fabrication of flexible borescope guide tube.

G. Material - Cost and Availability:

(1) Aircraft:

Parts and materials required to accomplish this modification are listed in paragraph 3.A and are to be procured as indicated. Parts bearing Douglas Aircraft Company part numbers are proprietary parts and must be procured under the spare parts article of the purchase agreement, unless methods of manufacture are shown.

Cost and availability of parts are to be negotiated between the operator and Douglas Aircraft Company. Reference this Service Bulletin number and direct inquiries to:

Douglas Aircraft Company
P.O. Box 1771
Long Beach, California 90801
Attn: Parts Sales - Commercial 73-44
(DC-9 Service Bulletin A53-232)

(2) Spares:

Not applicable.

H. Tooling - Price and Availability:

Inspection from Aft Side of Bulkhead

(1) Special test equipment is required to accomplish visual inspection outlined in this Service Bulletin. Special test equipment is to be procured from operator's stock, or other sources.

SAMPLE VISUAL INSPECTION PROCEDURE

(2) Procurement and availability of Special Test Equipment should be negotiated between the operator and the Douglas Aircraft Company. Specify this Service Bulletin number and direct inquiries to:

Douglas Aircraft Company
910 East 236th Street
Carson, California 92805
Attn: Manager, Recovery & Modification Services (RAMS)
(DC-9 Service Bulletin A53-232)

I. Weight and Balance:

Weight change at appropriate fuselage stations by incorporation of any part of this Service Bulletin is contingent upon the modification of each particular aircraft. Weight data is to be computed by the operator by weighing parts installed and parts removed during modification. Necessary revisions should be made to the appropriate weight and balance report.

J. Reference:

(1) Federal Aviation Administration Airworthiness Directive No. 89-16-12: Amendment 39-6287, effective September 7, 1989.

(2) Data used in preparation of this Alert Service Bulletin:

Data Identification	Change	Type of Data
DMS 2082		Douglas Material Specification
J060157	A	Service Rework Shoring
J060157	B	Advance E.O.
MM Chapters 6, 20, 21, 25, 26, 36, 49, 52, and 53		Maintenance Manual
NDT Chapter 1-3		Nondestructive Testing Manual
SRM Chapters 51 and 53		Structural Repair Manual
SR09530001	C	Service Rework Drawing
SR09530001	D	Advance E.O.
SR09530048	New	Service Rework Drawing
SR09530056	C	Service Rework Drawing
SR09530056	D	Advance E.O.
SR09530083	New	Service Rework Drawing
5910130	DY	Drawing
5930760	AM	Drawing

(3) Data supplied in support of this Alert Service Bulletin:

Data Identification	Change	Type of Data
J060157	A	Service Rework Shoring
J060157	B	Advance E.O.

SAMPLE VISUAL INSPECTION PROCEDURE

SR09530001	C	Service Rework Shoring
SR09530001	D	Advance E.O.
SR09530048	New	Service Rework Drawing
SR09530056	C	Service Rework Drawing
SR09530056	D	Advance E.O.
SR09530083	New	Service Rework Drawing

K. Publications Affected:

The modification outlined in this Service Bulletin affects the DAC DC-9 Weight and Balance Charts.

2. Accomplishment Instructions:

WARNING: TO AVOID INJURY TO MAINTENANCE PERSONNEL OR DAMAGE TO EQUIPMENT, MAKE CERTAIN ADEQUATE PRECAUTIONS ARE TAKEN WHILE PERFORMING ANY WORK IF ELECTRICAL POWER IS APPLIED TO THE AIRCRAFT.

CAUTION: ELECTRICALLY GROUND THE AIRCRAFT.

GENERAL NOTES:

1. Refer to sections of the Maintenance Manual (MM), Structural Repair Manual (SRM).

2. Refer to the following manual chapters for applicable operations:

Manual	Chapter	Operation
MM	20-30-0	Sealant Application
SRM	51-10-4	Drilling And Countersinking
SRM	51-30-1	Installing Bolts, Screws, and Washers
SRM	51-30-2	Removing And Installing Rivets
SRM	51-30-3	Removing And Installing Lockbolts
SRM	51-30-5	Removing And Installing Pins

3. For approved fastener and process material substitutions, see DC-9 SRM chapter 51-60-0, paragraph entitled "Interchangeability of Fasteners" and "Interchangeability of Materials."

4. If the length of the fasteners specified in this Service Bulletin do not meet acceptable installation standards, fasteners of the same type, or approved substitutions, one increment longer or shorter in length may be used.

or

A combined total of two (maximum) 1/16-inch thick washers or four (maximum) 1/32-inch thick washers or any combination thereof not exceeding 1/8-inch total stackup thickness of the washer types called from in this Service

SAMPLE VISUAL INSPECTION PROCEDURE

Bulletin may be used under fastener head or nut to counteract accumulation of tolerances.

5. If substitutions are used other than those in Douglas approved publications, operator must obtain FAA approval from local authorized agency.

Inspection from Aft Side of Bulkhead

A. Operator's Option - Access doors may be installed in skin on bottom of fuselage forward of auxiliary power unit (APU) door per service rework drawing SR09530048 to facilitate inspection.

B. Operator's Option - Fabricate guide tube (to be used with flexiscope) from flexible or thin wall tubing to fit outside diameter of flexiscope as shown on Figure 1.

C. Gain access to inspection areas on aft side of bulkhead by opening or removing and retaining the following access doors/panels as applicable to accomplish visual inspection:

Access No.	Access Area	MM Chapter
5806A	Auxiliary Exit Door, Non-Ventral Bulkhead	6-12-0
5901A	Thrust Reverser Control Valve (Left Side)	6-11-4
5902A	Thrust Reverser Control Valve (Right Side)	6-11-4
5903A	APU Service (Left Side)	6-11-4
5904A	APU Service (Right Side)	6-11-4
5910A	Ventral Stair Ceiling	6-12-0
5911A	Ventral Stair (Right Side)	6-12-0
5912A	Ventral Stair (Left Side)	6-12-0

NOTE: The following paragraphs 2.D through 2.H may be accomplished at operator's option and are applicable to visual inspection requirements.

D. Remove and retain APU and attaching parts. (See MM chapter 49-10-0, paragraph entitled "Removal/Installation Power Plant.")

E. Remove and retain APU compartment enclosure and attaching parts. (See MM chapter 53-20-5, paragraph entitled "Removal/Installation APU Compartment Enclosure.")

SAMPLE VISUAL INSPECTION PROCEDURE

F. Remove and retain lower firex bottle and attaching parts. (See MM chapter 26-20-1, paragraph entitled "Removal/Installation Fire Extinguishing Containers.")

G. Remove and retain right pneumatic crossfeed valve pushrod and attaching parts. (See MM chapter 36-10-3, paragraph entitled "Removal/Installation Pneumatic Crossfeed Valve.")

H. Remove and retain two upper conditioned air duct assemblies, check valves, and attaching parts aft of pressure bulkhead center ceiling. (See MM chapter 21-20-2, paragraph entitled "Removal/Installation Conditioned and Cold Air Check Valve.")

I. Roll back or remove and retain insulation blankets from aft side of aft pressure bulkhead. (See MM chapter 25-22-0, paragraph entitled "Removal/Installation Insulation Blankets.")

J. Perform optically aided visual inspection/repair of the aft pressure bulkhead web to fuselage skin attach tee sections from the aft side of the bulkhead as follows:

(1) Inspect the upstanding leg of 5910130 ventral bulkhead tee sections from aft side of bulkhead around the periphery of the bulkhead as shown on Figure 3 and accomplish the following:

<u>Condition 1 (No Crack)</u>

(2) Perform repetitive visual inspections from aft side of bulkhead at intervals specified in Compliance paragraph.

<u>Condition 2 (Crack)</u>

(3) Replace cracked tee section with new like or improved part per Figure 4 (See Table I for configuration) prior to further pressurized flight. Perform repetitive visual from aft side of bulkhead at intervals specified in Compliance paragraph.

(4) If any tee section is to be replaced, remove and retain engines 1 and 2. (See MM chapter 71-00-0, paragraph entitled "Removal/Installation Power Plant.")

(5) Shore aircraft as shown on Figure 5.

K. Record and report all results, both negative and positive of inspection to DAC. Include fuselage number, factor serial number, crack location, crack length, flight-hours, and accumulated landings of aircraft. Forward to:

Douglas Aircraft Company
P.O. Box 1771
Long Beach, California 90801
Attn: Manager, Customer Service 73-30
(DC-9 Alert Service Bulletin A53-232)

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SAMPLE VISUAL INSPECTION PROCEDURE

L. Apply PR-1422 B-2 sealant around entire periphery of the bulkhead tee sections, as applicable.

M. Reinstall retained insulation blankets on aft side of aft pressure bulkhead. (See MM chapter 25-22-0, paragraph entitled "Removal/Installation Insulation Blankets.")

N. Reinstall right pneumatic crossfeed valve pushrod and attaching parts as applicable. (See MM chapter 36-10-3, paragraph entitled "Removal/Installation Pneumatic Crossfeed Valve.")

O. Reinstall two upper conditioned air duct assemblies, check valves, and attaching parts as applicable. (See MM chapter 21-20-2, paragraph entitled "Removal/Installation Conditioned and Cold Air Check Valve.")

P. Reinstall lower firex bottle and attaching parts as applicable. (See MM chapter 26-20-1, paragraph entitled "Removal/Installation Fire Extinguishing Containers.")

Q. Reinstall APU compartment enclosure, as applicable. (See MM chapter 53-20-5, paragraph entitled "Removal/Installation APU Compartment Enclosure.")

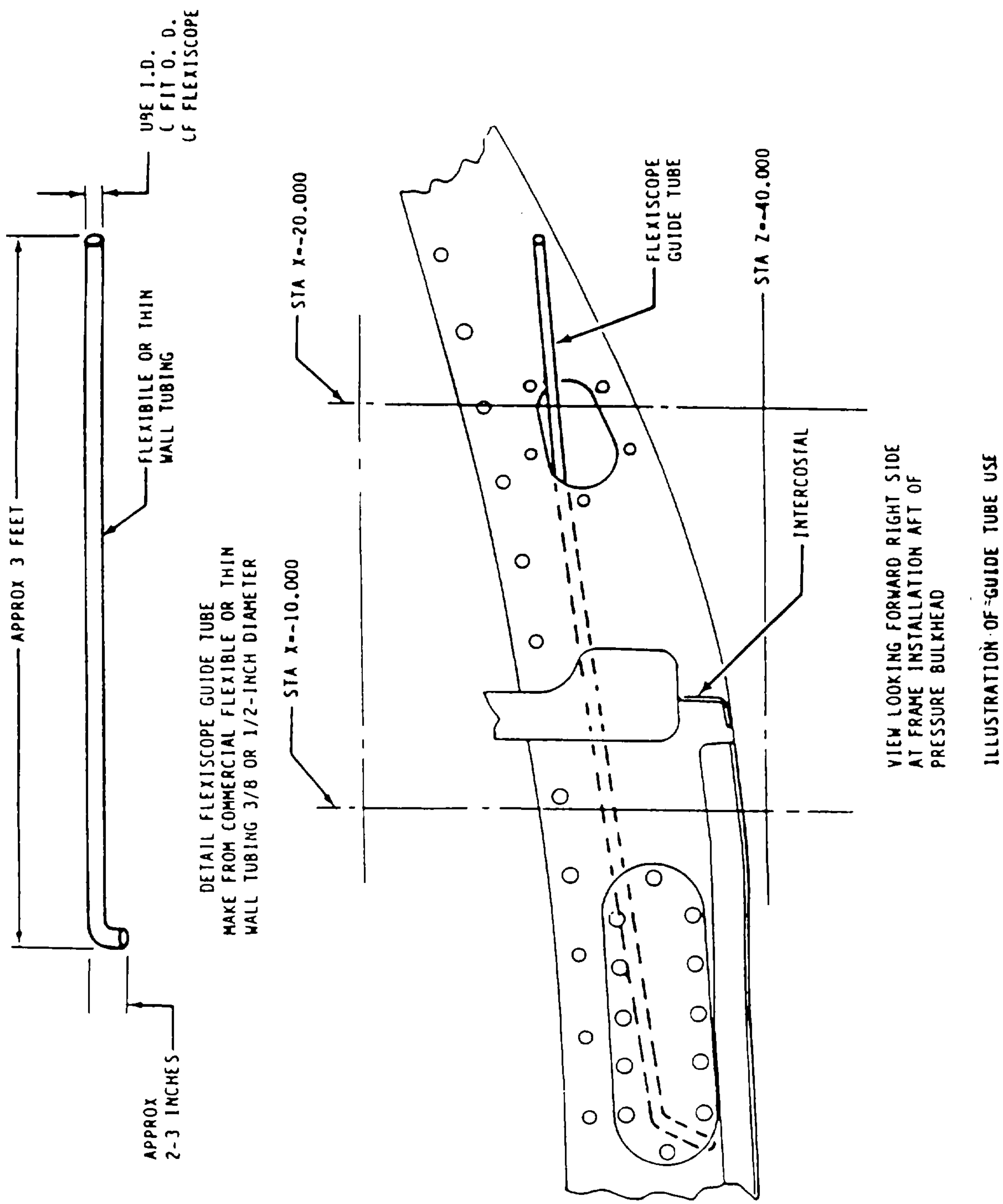
R. Reinstall APU and attaching parts as applicable. (See MM chapter 49-10-0, paragraph entitled "Removal/Installation Power Plant.")

S. Reinstall engines 1 and 2 as applicable. (See MM chapter 71-00-0, paragraph entitled "Removal/Installation Power Plant.")

T. Remove shoring as shown on Figure 5 as applicable.

U. Close/reinstall access doors/panels as outlined under Option I paragraph 2.C.

SAMPLE VISUAL INSPECTION PROCEDURE



FLEXIBLE BORESCOPE GUIDE TUBE - FABRICATION AND USE

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SAMPLE VISUAL INSPECTION PROCEDURE

GENERAL NOTES:

1. PERFORM INSPECTION PROCEDURE A, SEQUENCES 1 THROUGH 3 BEFORE CLEANING THE TEE AND AFTER CLEANING THE TEE AS NOTED.

2. PROCEDURE A - DESCRIBES AN OPTICALLY AIDED VISUAL INSPECTION OF DC-9 AFT PRESSURE BULKHEAD WEB TO FUSELAGE SKIN ATTACH TEE SECTIONS TO DETECT FATIGUE CRACKS IN THE UPSTANDING LEG OF TEE SECTIONS.

3. INSPECTION OF THE BULKHEAD TEE FOR CRACKS BY PROCEDURE A IS MADE FROM THE AFT SIDE OF THE AFT PRESSURE BULKHEAD.

4. INSPECTION BY PROCEDURE A IS DIVIDED INTO THREE SEQUENCES BASED ON ACCESS LOCATION.

5. SIGNS OF NICOTINE STAINS MAY INDICATE CRACKS.

6. THE FOLLOWING EQUIPMENT OR EQUIVALENT IS REQUIRED:

   SEE PARAGRAPH 3.C FOR TEST EQUIPMENT SUPPLIERS.

   VISUAL EQUIPMENT

   a. FLASHLIGHT.

   b. INSPECTION MIRROR WITH ADJUSTABLE VIEWING ANGLE.

   ENDOSCOPE EQUIPMENT:

   c. ONE 70 OR 90 DEGREE ENDOSCOPE OF ANY DIAMETER WITH 18-INCH (457.2 MM)) MINIMUM LENGTH AND LIGHT SOURCE SUCH AS:

      (1) ENDOSCOPE MODEL 10320D, 70 DEGREE (FOREOBLIQUE) ANGLE, 19-INCH (482.6 MM) LONG, 0.217-INCH DIAMETER.

      (2) FIBER OPTIC LIGHT BUNDLE MODEL 495NL.

      (3) ENDOSCOPE LIGHT SOURCE NUMBER 00482 (110 OR 220 VOLT) OR NUMBER E0590 (110 VOLT ONLY).

      (4) SYLVANIA PROJECTOR LAMP (150 WATT, 120 VOLT).

AFT PRESSURE BULKHEAD TEE - INSPECTION

FIGURE 3 (SHEET 1 OF 14)

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SAMPLE VISUAL INSPECTION PROCEDURE

FLEXIBLE BORESCOPE:

d. ONE FORWARD VIEWING ENDOSCOPE OF ANY DIAMETER WITH 30 INCH MINIMUM LENGTH SUCH AS:

(1) OLYMPUS MODEL 1F8D3, 29.8-INCH (757 MM) LONG, 0.315-INCH DIAMETER.

(2) COLD LIGHT SUPPLY NUMBER 1LK-4 (100 TO 230 VOLT).

INSPECTION PROCEDURE

A. VISUAL INSPECTION PROCEDURE A:

SEQUENCE 1:

(1) PERFORM MIRROR/FLASHLIGHT OR ENDOSCOPE INSPECTION OF UPPER FUSELAGE TEE SECTIONS FROM LONGERON L7 LEFT SIDE TO LONGERON L7 RIGHT SIDE, LOWER FUSELAGE LONGERON L17 LEFT SIDE TO LONGERON L20 LEFT SIDE, AND LONGERON L17 RIGHT TO LONGERON L19 RIGHT SIDE.

(2) PERFORM ENDOSCOPE OR FLEXIBLE BORESCOPE INSPECTION OF LOWER FUSELAGE TEE SECTIONS FROM LONGERON L19 RIGHT SIDE TO LONGERON L20 RIGHT SIDE.

SEQUENCE 2:

(1) PERFORM MIRROR/FLASHLIGHT OR ENDOSCOPE INSPECTION OF LOWER FUSELAGE TEE SECTION THROUGH THRUST REVERSER LOCKOUT ACCESS OPENING 5902A FROM LONGERON L20 RIGHT SIDE TO LONGERON L24 RIGHT SIDE.

NOTE: SEQUENCE 2 AND 3 MAY BE ACCOMPLISHED USING INSPECTION MIRROR AND FLASHLIGHT IF SUFFICIENT ACCESS IS AVAILABLE.

AFT PRESSURE BULKHEAD TEE - INSPECTION

FIGURE 3 (SHEET 2 OF 14)

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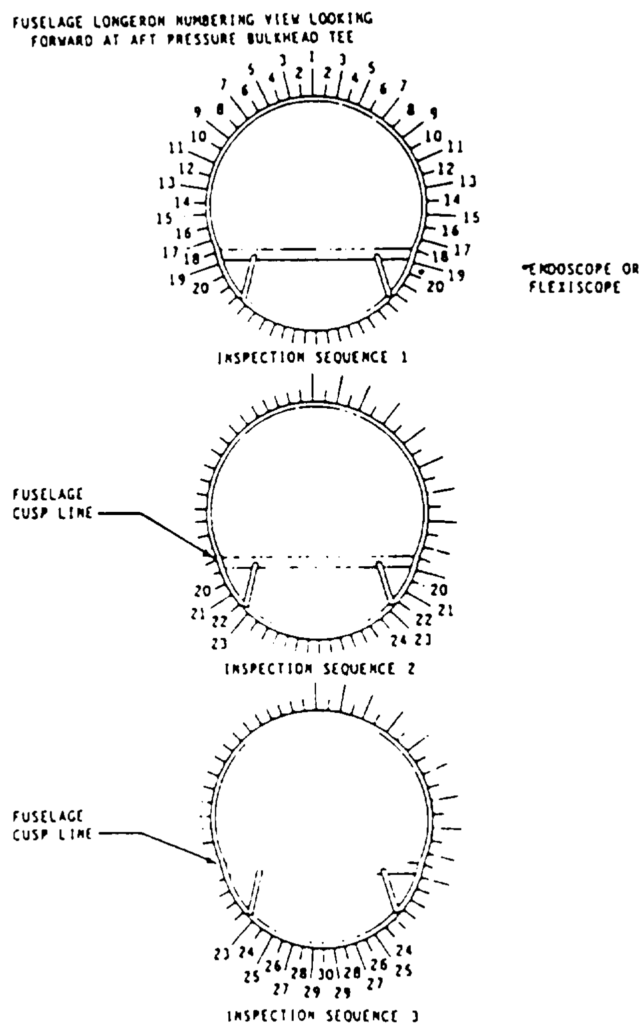
SAMPLE VISUAL INSPECTION PROCEDURE

SEQUENCE 3:

(1) PERFORM VISUAL INSPECTION OF LOWER FUSELAGE TEE SECTIONS WITH FLASHLIGHT FROM LONGERON L23 LEFT SIDE TO LONGERON L24 RIGHT SIDE.

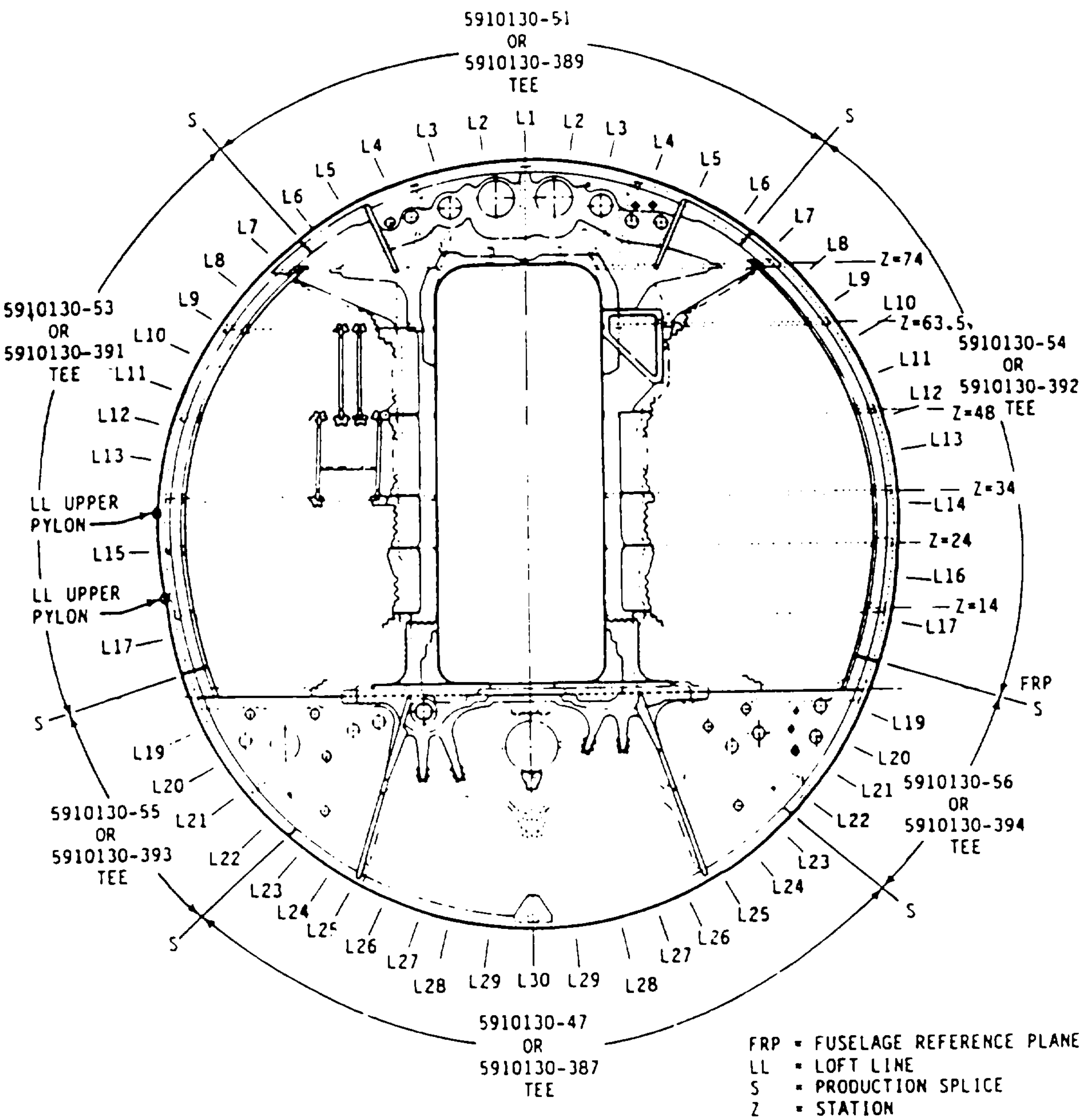
REMOVE SEALANT FROM INSPECTION AREA OF TEE SECTIONS THAT MAY HINDER INSPECTION. CLEAN DIRT, GREASE, AND ALL FOREIGN MATERIALS FROM INSPECTION AREA OF TEE SECTIONS USING LINT-FREE WIPER AND 1.1.1 TRICHLOROETHANE SOLVENT OR EQUIVALENT. PERFORM INSPECTION SEQUENCES 1 THROUGH 3 AFTER CLEANING THE TEE SECTIONS.



AFT PRESSURE BULKHEAD TEE - INSPECTION

FIGURE 3 (SHEET 3 OF 14)

SAMPLE VISUAL INSPECTION PROCEDURE



VIEW LOOKING FORWARD

DC-9 VENTRAL AFT PRESSURE BULKHEAD SCHEMATIC DIAGRAM SHOWING TEE LOCATIONS

AFT PRESSURE BULKHEAD TEE - INSPECTION

FIGURE 3 (SHEET 4 OF 14)

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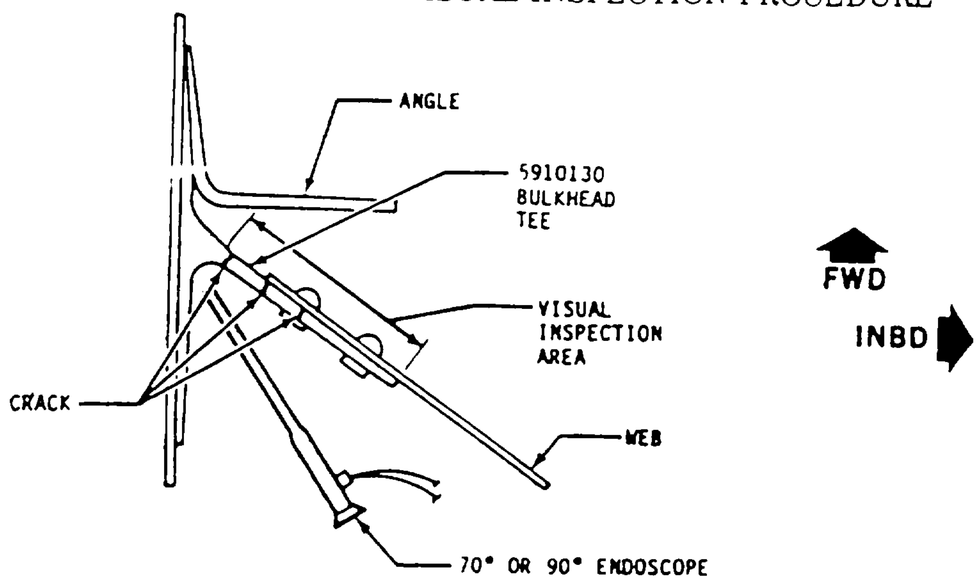
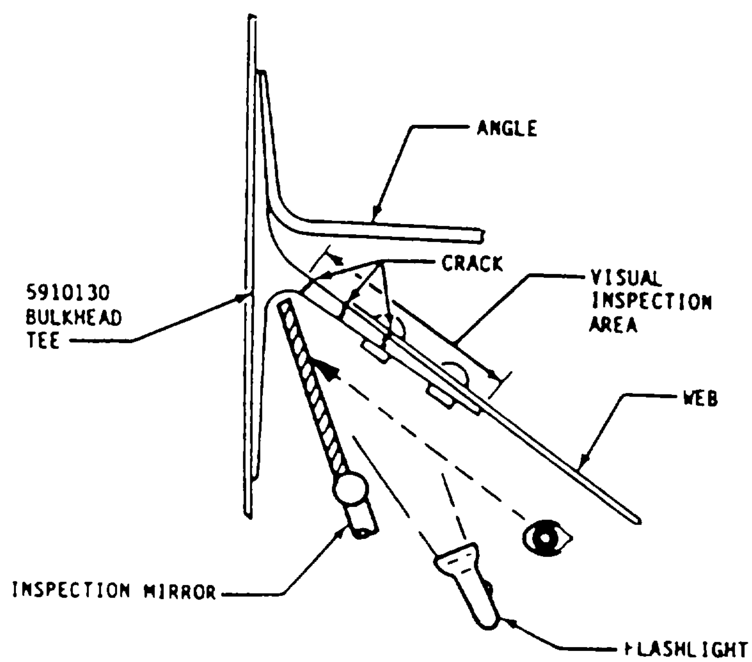
SAMPLE VISUAL INSPECTION PROCEDURE



DETAIL A - ENDOSCOPE VISUAL INSPECTION



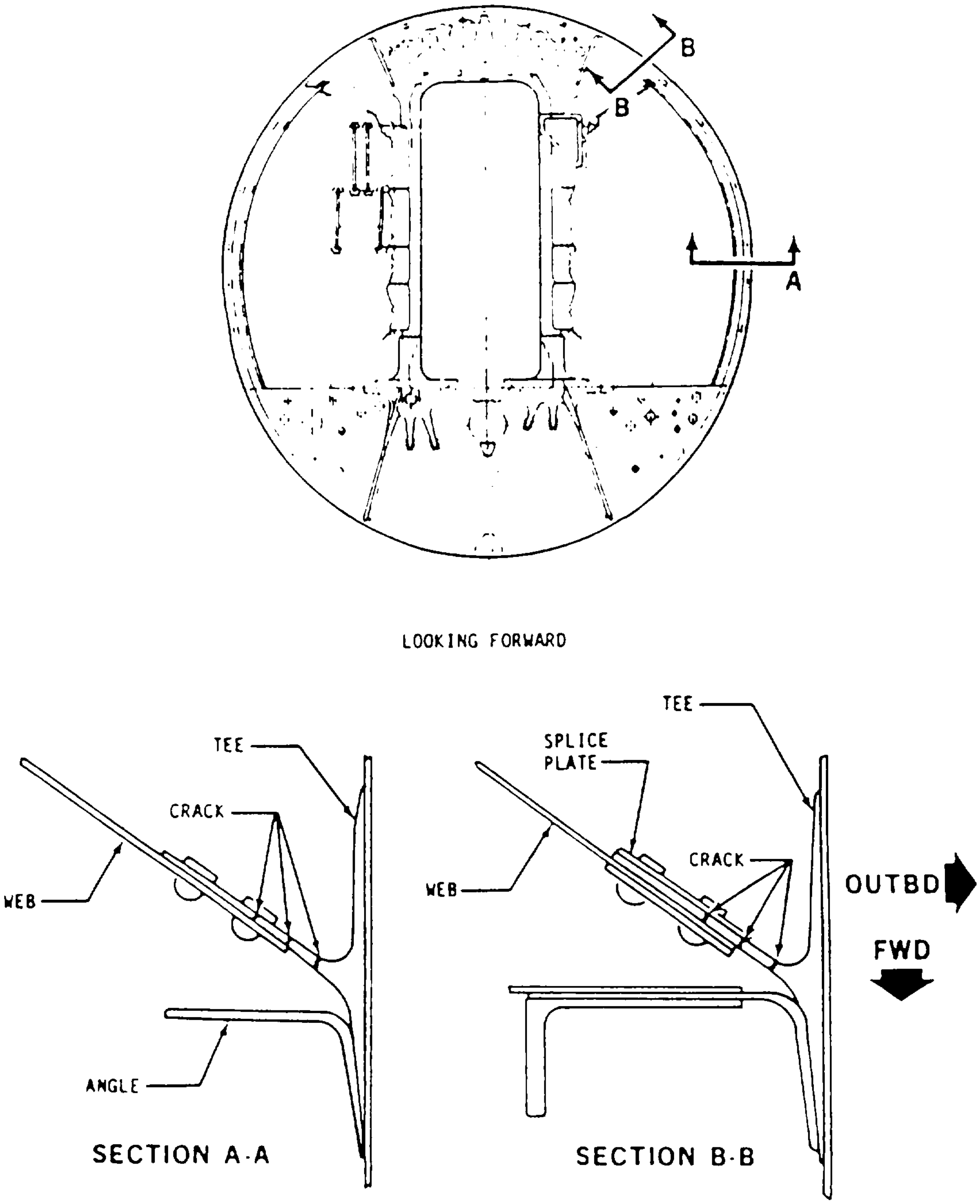
DETAIL B - MIRROR FLASHLIGHT VISUAL INSPECTION

SEQUENCE 1 VISUAL AND ENDOSCOPE INSPECTION OF BULKHEAD TEE

AFT PRESSURE BULKHEAD TEE - INSPECTION

FIGURE 3 (SHEET 5 OF 14)

SAMPLE VISUAL INSPECTION PROCEDURE



DC-9 VENTRAL AFT PRESSURE BULKHEAD. TEE CAP CRACKS

AFT PRESSURE BULKHEAD TEE - INSPECTION

FIGURE 3 (SHEET 6 OF 14)

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SAMPLE VISUAL INSPECTION PROCEDURE

C. The basis for the following tooling data is per operator.

NOTE: CAGE indicates Commercial and Government Entity code for Manufacturers/Distributors.

(1) Option I - Test equipment to be procured from operator's stock or sources indicated.

Test Equipment	Type	Qty	CAGE	Supplier
Endoscope 70 Degree (Fore oblique) Angle 19-Inch (482.6 MM) Long 0.217-Inch Diameter or Equivalent	Model 10320D	1	54341	Expanded Optics, Incorporated 301-C West Dyer Road Santa Ana, California 92702-3427

NOTE: One 70 or 90 degree endoscope of any diameter with 18-inch (457.2 MM) minimum length and matching light source may be used.

Test Equipment	Type	Qty	CAGE	Supplier
Fiber Optic Light Bundle	Model 1F8D3	1	54341	Expanded Optics, Incorporated 301-C West Dyer Road Santa Ana, California 92702-3427
and Endoscope Light Source 110 or 220 Volt	No. 00482 or No. E0590		54341	Expanded Optics, Incorporated 301-C West Dyer Road Santa Ana, California 92702-3427
and Sylvania Projector Lamp 150 Watt, 120 Volt		1	54341	Expanded Optics, Incorporated 301-C West Dyer Road Santa Ana, California 92702-3427

NOTE. Similar or equivalent endoscopes and illuminators may be obtained from the following sources.

SAMPLE VISUAL INSPECTION PROCEDURE

Test Equipment	Type	Qty	CAGE	Supplier
				Alva Ingenieros Velazquez 121 Madrid 6, Spain or Automation Instruments Service 47 Birch Street Bankston 2200, Australia or 3 G Electronics Sede Commercial 20135 Milano Via Perugino 9, Italy or
			50958	Richard Wolf Medical Instrument Corporation 7046 Lyndon Avenue Rosemont, Illinois 60018-3410 or Inspection Instruments NDT Limited 32 Duncan Terrace London N188R, England or Karl Storz KG D 7200 Tuttlingen West Germany
Flexible Borescope 29.8-Inch (757 MM) Long 0.315-Inch Diameter	Model 1F8D3	1	32212	Olympus Corporation Scientific Products Group 4 Nevada Drive Lake Success, New York 11040-1114
Cold Light Supply 100 to 230 Volt	No. 1LK-4	1	32212	Olympus Corporation Scientific Products Group 4 Nevada Drive Lake Success, New York 11040-1114
or Equivalent				

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APPENDIX F. BOEING 747 SERVICE BULLETIN SAMPLE INSPECTION PROCEDURE

Excerpts of Boeing Service Bulletin 747-53-2307, Dec 21/89.

Retyped with permission of Boeing Commercial Airplane Group.

SAMPLE VISUAL INSPECTION PROCEDURE

BOEING 747

SERVICE BULLETIN

SUMMARY

BOEING COMMERCIAL AIRPLANES POST OFFICE BOX 3707 SEATTLE, WASHINGTON 98124-2207

BACKGROUND

This inspection will detect corrosion and fatigue cracks in upper body skin longitudinal lap joints caused by disbonding of the cold bond at the joint. Continued operation of an airplane that has corrosion or fatigue cracking in lap joints could lead to separation of the skin at the lap joint causing rapid decompression of the airplane.

Several operators have reported corrosion, and associated bulging of skin at upper body lap joints on airplanes with 26,733 to 70,000 flight-hours. One operator reported cracking and corrosion of the lap joint at Stringer 12 from Station 1515 to 1735 and Stringer 4L at Station 1710 on an airplane with 35,134 flight-hours. One other operator reported corrosion and cracking at the lap joint at Stringer 4R, Station 1500 on an airplane with 49,024 flight-hours. Another operator reported a one-inch crack at Stringer O, Station 738 suspected to have been caused by corrosion from disbonding at the cold-bonded lap joint. There have been numerous additional instances of corrosion reported at the Stringer 23 lap joint.

This bulletin supersedes that portion of Service Bulletin 747-53-2157 which addresses the upper body skin longitudinal lap joints.

Airplanes previously inspected per Service Bulletin 747-53-2157 require additional inspection of lap joint areas as described herein.

Any lap joint areas repaired per Service bulletin 747-53-2157 do not require further repair or inspection.

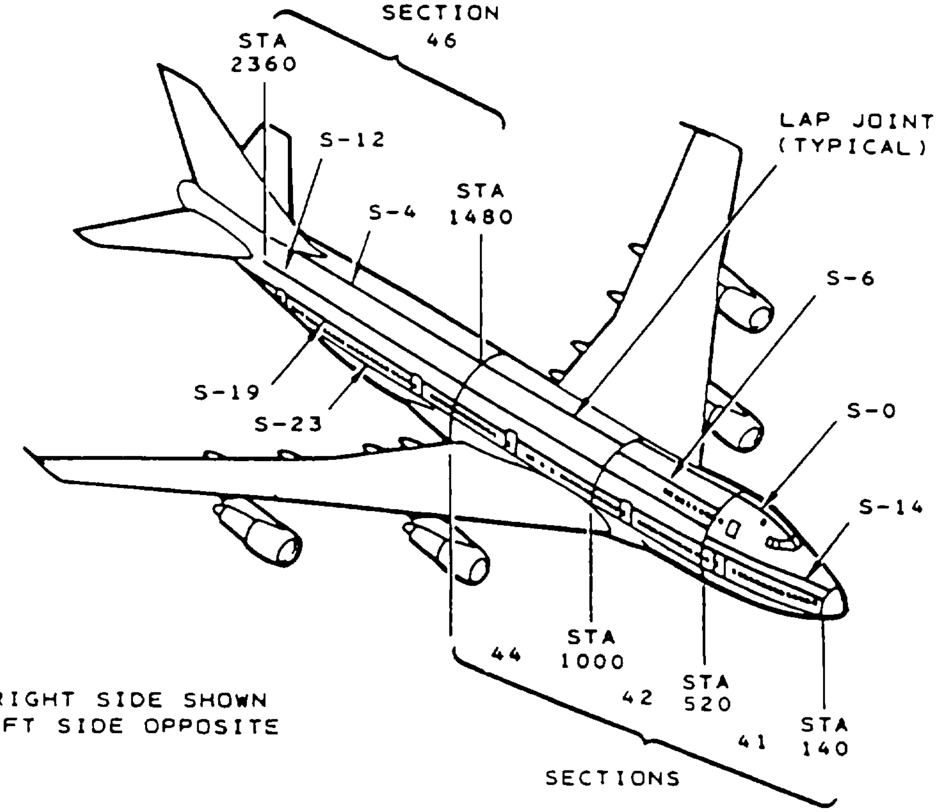
This bulletin does not supersede Service Bulletin 747-53-2253 or Service Bulletin 747-53A2303 which address the upper body skin longitudinal lap joints at Stringer 6 in Section 41.

This service bulletin is the subject of Federal Aviation Administration (FAA) Notice of Proposed Rulemaking 88-NM-194-AD dated February 9, 1989.

ACTION

Within 1,000 flight-cycles after receipt of this bulletin, conduct a detailed external visual inspection of the upper body longitudinal lap joints at Stringers 23 and above from Station 140 to 2360 (except Stringer 7 from Station 340 to 520). Visually inspect all lap joints for evidence of corrosion or cracking. Evidence of corrosion includes missing or distressed fasteners, white powder protruding from the lap joint, or bulging or pillowing of the lap joint between fasteners. Repair any corrosion beyond allowable limits or cracking, as specified herein, prior to further flight. Repeat these visual inspections at intervals not to exceed 1,000 flight-cycles for the lap joints in Sections 41, 42, and 46. Repeat the visual inspections at 2,000 flight-cycle intervals for the lap joints in Section 44.

BOEING SERVICE BULLETIN 747-53-2307



INSPECT LAP JOINTS FOR CORRORSION, CRACKS OR PILLOWING
OF SKIN, AND MISSING OR DISTRESSED FASTENERS

BOEING SERVICE BULLETIN 747-53-2307

In lieu of continued reinspections, terminating action may be accomplished. Terminating action is accomplished when an uncorroded lap joint area is separated between adjacent circumferential splices, adhesive removed, faying surface sealant is applied, and joint is refastened per 747 Structural Repair Manual Subject 43-30-03. Terminating action in a corroded or cracked lap joint area may be accomplished when the area is repaired per 747 Structural Repair Manual Subject 53-30-03.

EFFECTIVITY

747 Airplanes line position 001 through 200

MANPOWER

Visual Inspection:
Total Manhours - 152 per Airplane
Elapsed Time - 38 Hours

MATERIAL INFORMATION

None.

BOEING SERVICE BULLETIN 747-53-2307

BOEING COMMERCIAL AIRPLANES POST OFFICE BOX 3707 SEATTLE, WASHINGTON 98124-2207

SERVICE BULLETIN

747

ATA SYSTEM: 5310
5331

NUMBER: 747-53-2307

DATE: December 21, 1989

SUBJECT: FUSELAGE - SKIN - UPPER BODY SKIN LONGITUDINAL LAP JOINT (STRINGERS 23 AND ABOVE) INSPECTION AND REPAIR

I. PLANNING INFORMATION

A. Effectivity

1. Airplanes Affected

See Service Bulletin Index Part 3 for cross reference of Variable Number to Airplane Serial Number.

This change is applicable only to airplanes listed below.

CODE	VARIABLE NUMBER			
ACN	RA743			
AFA	RA251-RA259			
AIN	RA722-RA724			
ARL	RA203	RA501-RA502		
BAB	RA217 RA702	RA301-RA308	RA310	RA312
CAL	RA51-RA552			
CLX	RA023	RA025		

BOEING SERVICE BULLETIN 747-53-2307

CODE	VARIABLE NUMBER (CONTINUED)			
ELA	RA781-RA782	RB043		
EVR	RA003-RA004	RA022	RA113	
FTL	RA026	RA029	RA033	RA632
	RA634-RA635	RA741	RA916	RB041
IBE	RA585			
IRN	RA101-RA103	RA112	RA161-RA163	
JAL	RA521-RA527	RA532-RA534	RA537-RA540	
KAL	RA216	RA245	RA201	
KLM	RA671-RA675	RA677		
MNR	RA701			
NAS	RA908			
NWA	RA351-RA360	RA369-RA373	RA601-RA602	
ORI	RA020			
PAA	RA002	RA005-RA007	RA009	RA012-RA019
	RA027-RA028	RA030-RA032	RA034	
	RA631	RA633	RA910	RA914
PEX	RA559	RA561	RB003-RB005	
QAN	RA909	RB001-RB002		
SAA	RB071-RB075			
SAB	RB101-RB102			
TWO	RA024	RA201	RA761	RB042
TWA	RA104-RA110	RA114-RA115	RA164	RA309
	RA311	RA581-RA582	RA651-RA652	RD001-RD002
UAL	RA406-RA414	RA903-RA907		
UPS	RA901-RA902	RA911-RA913	RA915	
VAA	RA560			
WDA	RA742	RA762	RB044	

BOEING SERVICE BULLETIN 747-53-2307

CODE VARIABLE NUMBER (CONTINUED)

LISTING BY VARIABLE NUMBER

RA002-RA034	RA101-RA115	RA161-RA164	RA201-RA203	RA216-RA217
RA245-RA246	RA251-RA259	RA301-RA312	RA351-RA360	RA369-RA373
RA401-RA414	RA501-RA502	RA521-RA527	RA532-RA540	RA551-RA552
RA559-RA561	RA581-RA582	RA585	RA601-RA602	RA631-RA635
RA651-RA652	RA671-RA677	RA701-RA702	RA721-RA724	RA741-RA743
RA761-RA762	RA781-RA782	RA901-RA916	RB001-RB005	RB041-RB044
RB071-RB075	RB101-RB102	RD001-RD002	RR201	

2. Spares Affected

None

B. **Reason**

This inspection will detect corrosion or cracking in upper body skin longitudinal lap joints caused by disbonding of the cold bond at the lap joint. Continued operation of an airplane that has corrosion or cracking in lap joints could lead to separation of the skin at the lap joint causing rapid decompression of the airplane.

Several operators have reported corrosion, and associated bulging of skin at upper body lap joints on airplanes with 26,733 to 70,000 flight-hours.

One operator reported corrosion of one to three lap joint rivets and bulging of the skin at Stringer 12 near Station 1694 on an airplane with 34,827 flight-hours. This operator also reported cracked and corroded fuselage skin with separation at the lap joint at Stringer 12 L and R at six locations each side from Station 1515 to 1735 and Stringer 4L at Station 1710 on the same airplane with 35,134 flight-hours.

Another operator reported a one-inch skin crack emanating from the lap joint at Stringer 0 near Station 738 on an airplane with 49,800 flight-hours which was suspected to have been caused by corrosion from disbonding at the cold-bonded lap joint (Ref. SIIA 747-71). This operator also reported two airplanes with skin corrosion of lap joint at Stringer 4L. On one airplane, with 35,985 flight-hours, this corrosion was found at four locations between Stations 1482 and 1676. On the other airplane, corrosion was found near Stations 1510 and 1615 on an airplane with 36,461 flight-hours.

Also an operator has reported skin corrosion in the lap joint at Stringer 23R near Station 1400 on an airplane with 26,733 flight-hours and skin corrosion with bulging skin involving the lap joint at Stringer 23L between Station 1720 and 1820 on another airplane.

There have been numerous additional instances of corrosion reported at the Stringer 23 lap joint.

BOEING SERVICE BULLETIN 747-53-2307

B. (Continued)

This bulletin supersedes that portion of Service Bulletin 747-53-2157 which addresses the upper body skin longitudinal lap joints.

Airplanes previously inspected per Service Bulletin 747-53-2157 require additional inspection of lap joint areas as described herein.

Any lap joint areas repaired per Service Bulletin 747-53-2157 do not require further repair or inspection.

This bulletin does not supersede Service Bulletin 747-53-2253 or Service Bulletin 747-53A2303 which address the upper body skin longitudinal lap joints at Stringer 6 in Section 41.

This service bulletin is the subject of Federal Aviation Administration (FAA) Notice of Proposed Rulemaking 88-NM-1954-AD dated February 9, 1989.

C. **Description**

Within 1,000 flight-cycles after receipt of this bulletin, conduct a detailed external visual inspection of the upper body longitudinal lap joints at Stringers 23 and above from Station 340 to 520). Visually inspect all lap joints for evidence of corrosion or cracking. Evidence of corrosion includes missing or distressed fasteners, white powder protruding from the lap joint, or bulging or pillowing of the lap joint between fasteners. Repair any corrosion beyond allowable limits or cracking, as specified herein, prior to further flight. Repeat these visual inspections at intervals not to exceed 1,000 flight-cycles for the lap joints in Sections 41 (Station 140-520), 42 (Station 520-1000), and 46 (Station 1480-2360). Repeat the visual inspections at 2,000 flight-cycle intervals for the lap joints in Section 44 (Station 1000-1480).

In lieu of continued reinspections, terminating action may be accomplished. Terminating action is accomplished when an uncorroded lap joint area is separated between adjacent circumferential splices, adhesive removed, faying surface sealant is applied, and joint is refastened per 747 Structural Repair Manual Subject 53-30-03. Terminating action in a corroded or cracked lap joint area may be accomplished when the area is repaired per 747 Structural Repair Manual Subject 53-30-03.

It is recommended that this service bulletin be accomplished concurrently with service bulletins 747-53A2265 and 747-53A2279 due to common access.

This service bulletin is the subject of Federal Aviation Administration (FAA) Notice of Proposed Rule Making, FAA Docket Number 88-NM-194-AD, issued February 9, 1989.

D. **Approval**

This service bulletin has been reviewed by the Federal Aviation Administration (FAA) and the repairs and modifications herein comply with the applicable Federal Aviation Regulations (FAR's) and are FAA approved.

BOEING SERVICE BULLETIN 747-53-2307

D. (Continued)

The deferral of repair described in Accomplishment Instructions, has FAA approval contingent on accomplishment of the inspections at the intervals specified in the Accomplishment Instructions.

E. **Manpower**

The following breakdown of manpower requirements is suggested as a guide to assist operators in planning and accomplishing this modification. This estimate is for direct labor performed by an experienced crew. It does not include setup, planning, familiarization, cure time, part fabrication, tool acquisition, or lost time. Factor this estimate as necessary based on your own experience.

Operation	Crew size	Man-Hours	Elapsed Time (Hours)
Visual Inspection of Lap Joints	4	152	38
TOTAL PER AIRPLANE (a)		152	38

(a) Crew size, man-hour and elapsed time shown does not include time for lap joint repair or access to accomplish such repair since it is dependent on the extent of repairs required. It is assumed that operators will not perform terminating action on all lap joint areas at one time. Therefore, crew size, man-hours and elapsed time should be based on operator's experience and on the length and location of the lap joint for which terminating action is accomplished. Accomplishment of terminating action is estimated to be 96 man-hours for each 200-inch length of uncracked and uncorroded lap joint.

F. **Material - Price and Availability**

None

G. **Tooling - Price and Availability**

None

H. **Weight and Balance**

No change

BOEING SERVICE BULLETIN 747-53-2307

I. **References**

1. Existing Data:

a. 747 Maintenance Manual Subjects
25-11-01, 25-11-02, 25-11-03, 25-11-05, 25-14-01, 25-19-00, 25-21-01, 25-21-02, 25-21-04, 25-21-12, 25-22-01, 25-22-03, 25-22-06, 25-23-01, 25-23-04, 25-23-05, 25-24-00, 25-24-05, 25-24-11, 25-24-12, 25-24-19, 25-25-01, 25-25-03, 25-25-04, 25-26-02, 25-26-03, 25-26-06, 25-27-00, 25-28-01, 25-28-15, 25-28-23, 25-31-04, 25-40-01, 25-40-03, 25-59-01, 25-68-02, 31-00-00, 34-11-00, 35-00-00, 35-21-00, 52-11-01, 52-13-01, 52-51-01, 53-21-01, 53-21-02.

b. 747 Structural Repair Manual Subjects 51-10-01, 53-30-03

c. 747 Non-Destructive Test Manual D6-7170

d. 747 Structural Item Interim Advisory 747-71

e. Boeing Service Bulletins 747-53-2157, "Body Longitudinal Skin Lap Joints, Tear Strap/Skin Lap Splices, Window Forgings, Skin Panel Doublers, And Selected Skin Panel Corrosion Inspection"; 747-53-2253, "Fuselage - Nose Section - Station 340 to 400 Stringer 6 Skin Inspection and Modification"; 747-53A2265, "Fuselage - Nose Section 41 - Body Frame Structure Inspections and Crack Repairs"; 747-53A2279, "Fuselage - Skin - Upper Body Skin Bonded Tear Strap Inspection and Modification"; 747-53A2303, "Fuselage - Nose Section -Station 400 to 520 Stringer 6 Skin Splice Inspection Repair and Modification"

f. FAA Notice of Proposed Rule Making, FAA Docket Number 88-NM-194-AD, issued February 9, 1989

2. Data supplied in support of this service bulletin:

None

J. **Publications Affected**

Publication	Chapter-Section
747 Corrosion Prevention Manual	53-30-47

BOEING SERVICE BULLETIN 747-53-2307

II. MATERIAL INFORMATION

A. **Parts Required Per Airplane**

None

B. **Parts Required to Modify Spares**

None

C. **Special Tools and Equipment Required**

No special tools or equipment are required to accomplish this bulletin. Maintenance and overhaul tools may be required per any manuals that are listed in Paragraph I.1., References, of this bulletin. Operators should review their tool inventory to ensure tool availability.

D. **Existing Parts Accountability**

None

BOEING SERVICE BULLETIN 747-53-2307

III. ACCOMPLISHMENT INSTRUCTIONS

NOTES:

1. The following paragraphs outline the general accomplishment instructions. The suggested sequence of operations and detailed accomplishment instructions are indicated by circle notes on the figures.

2. Observe all warning and caution notes in the referenced manual sections.

3. Figure 1 contains the Logic Diagram presentations of the following general accomplishment instructions.

A. For all lap joints affected by this bulletin as identified by Figure 2, perform inspection of the lap splices using the method outlined in the logic diagrams of Figure 1.

Method I

Within 1,000 flight-cycles after receipt of this bulletin, perform a detailed external visual inspection of the affected lap splices per Figure 2 circle notes 1 and 3. Repair any corrosion beyond limits or cracking as specified in Figure 2 circle note 3. Repeat the detailed external visual inspection at intervals not to exceed 1,000 flight-cycles for the affected lap splices in Section 41, 42, and 46. Repeat the detailed external visual inspection at intervals not to exceed 2,000 flight-cycles in Section 44.

B. In lieu of continued reinspections, terminating action may be accomplished. Terminating action is accomplished when an uncorroded lap joint area is separated between adjacent circumferential splices, adhesive removed, faying surface sealant is applied, and joint is refastened per 747 Structural Repair Manual Subject 53-30-03 Figure 9 or 10. Terminating action in a corroded or cracked lap joint area may be accomplished when the area is repaired per 747 Structural Repair Manual Subject 53-30-03. Internal lap joint access to accomplish terminating action can be made per Figures 3 through 5.

NOTES:

1. When accomplishing terminating action either with airplane in a specific jacked position or without jacking the airplane, contact Boeing for allowable length of lap joint which may be reworked (specify details of airplane configuration including weight and CG, jacking configuration, and any other work being performed concurrently on the airplane).

2. When accomplishing terminating action on a specific lap joint length, contact Boeing for jacking requirements (specify lap joint being reworked, details of airplane configuration including weight and CG, and any other work being performed concurrently on the airplane).

BOEING SERVICE BULLETIN 747-53-2307

3. When refastening lap joint per Structural Repair Manual Subject 53-30-03 Figure 9 or 10, perform open hole HFEC inspection per 747 Non-Destructive Test Manual D6-7170, Part 6, 53-30-00, Figure 1, 3 or 4 to ensure the lap joint is crack free prior to resizing hole for installation oversize protruding head fasteners.

C. Restore airplane to normal configuration.

BOEING SERVICE BULLETIN 747-53-2307

Illustration Table of Contents

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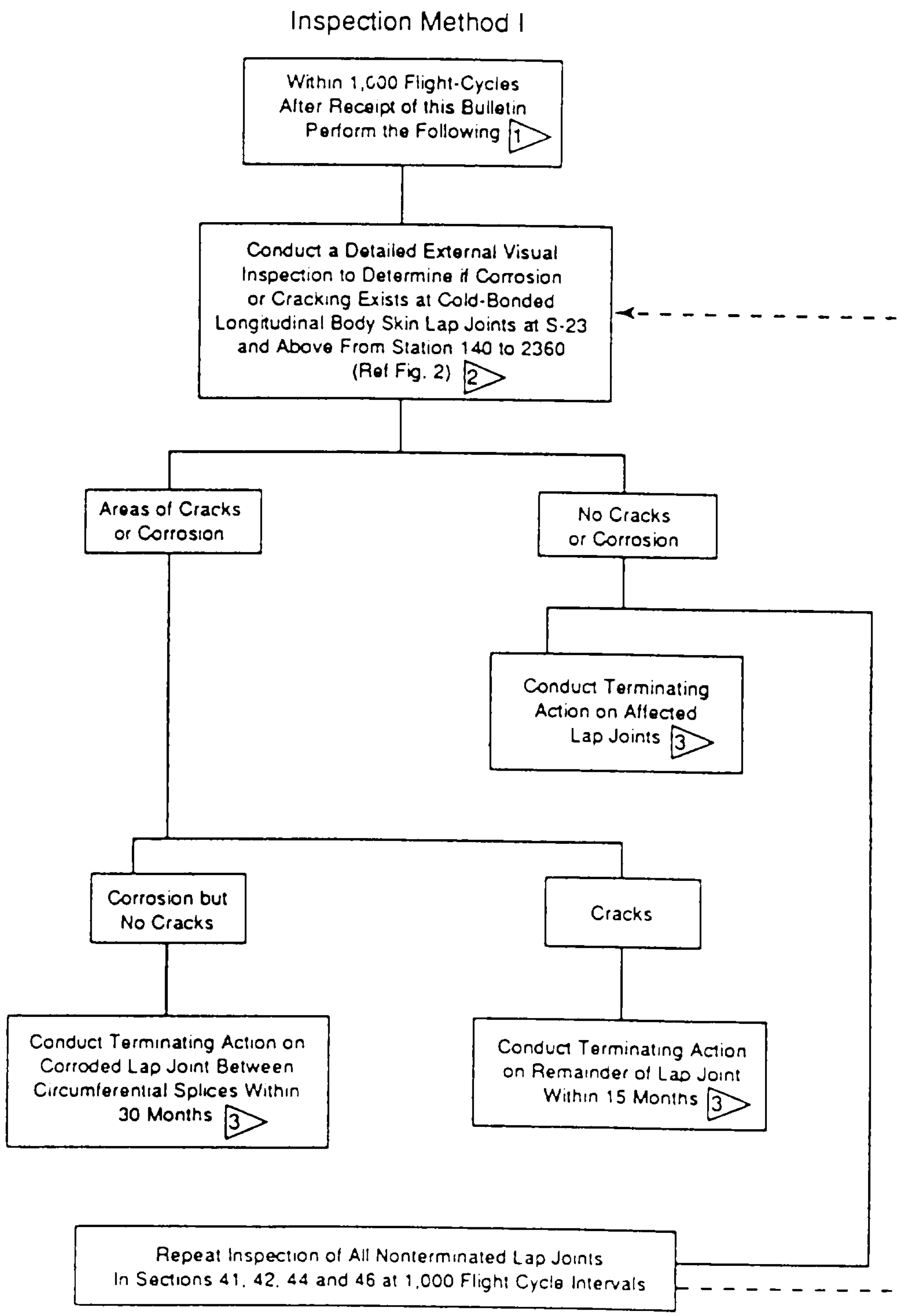
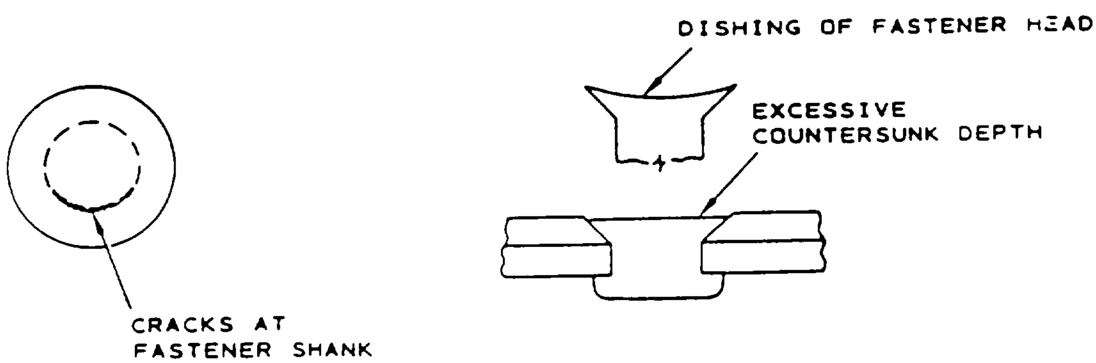


FIGURE 1. EXTERNAL LAP JOINT INSPECTION LOGIC DIAGRAM

BOEING SERVICE BULLETIN 747-53-2307



2. Measuring of pillowing is accomplished by using a suitable straight edge and thickness gage. Minimum length of straight edge should be 4.50 inches. See below:

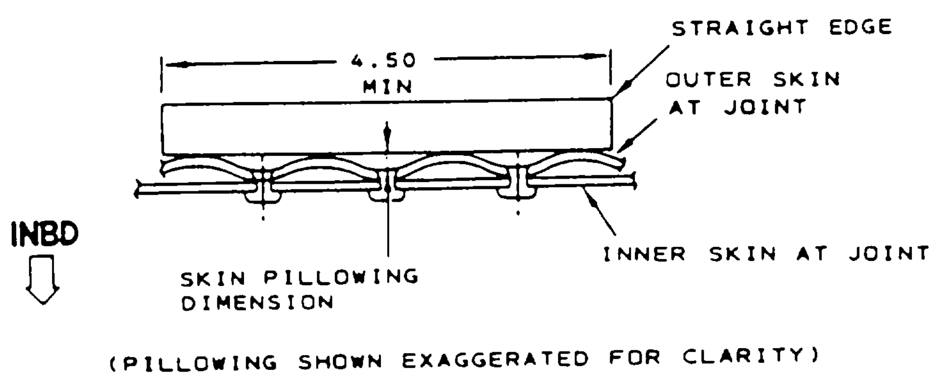


FIGURE 1. EXTERNAL LAP JOINT INSPECTION (CONTINUED)

BOEING SERVICE BULLETIN 747-53-2307

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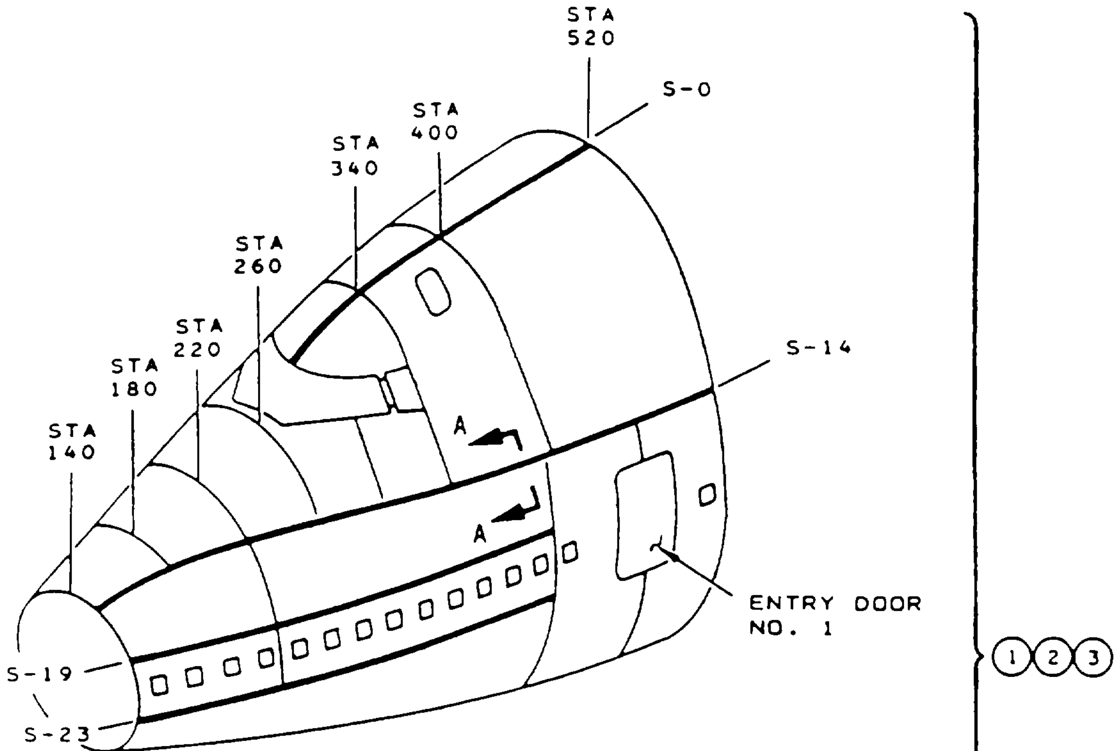
BOEING SERVICE BULLETIN 747-53-2307



Indicates area of visual inspections. 1

SECTION 41
LEFT SIDE

FIGURE 2. EXTERNAL LAP JOINT CORROSION INSPECTION

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747-53-2307

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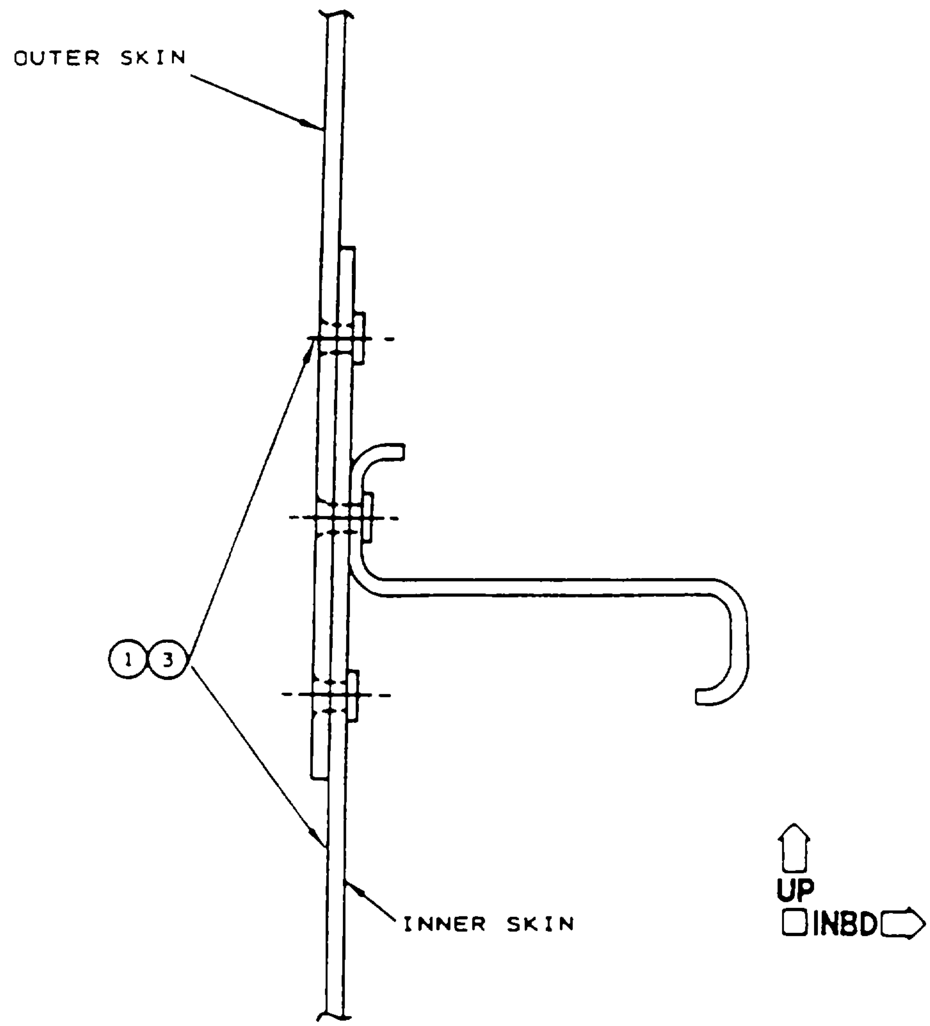


TYPICAL LAP JOINT

SECTION A-A

FIGURE 2. EXTERNAL LAP JOINT CORROSION INSPECTION (CONTINUED)

BOEING SERVICE BULLETIN 747-53-2307

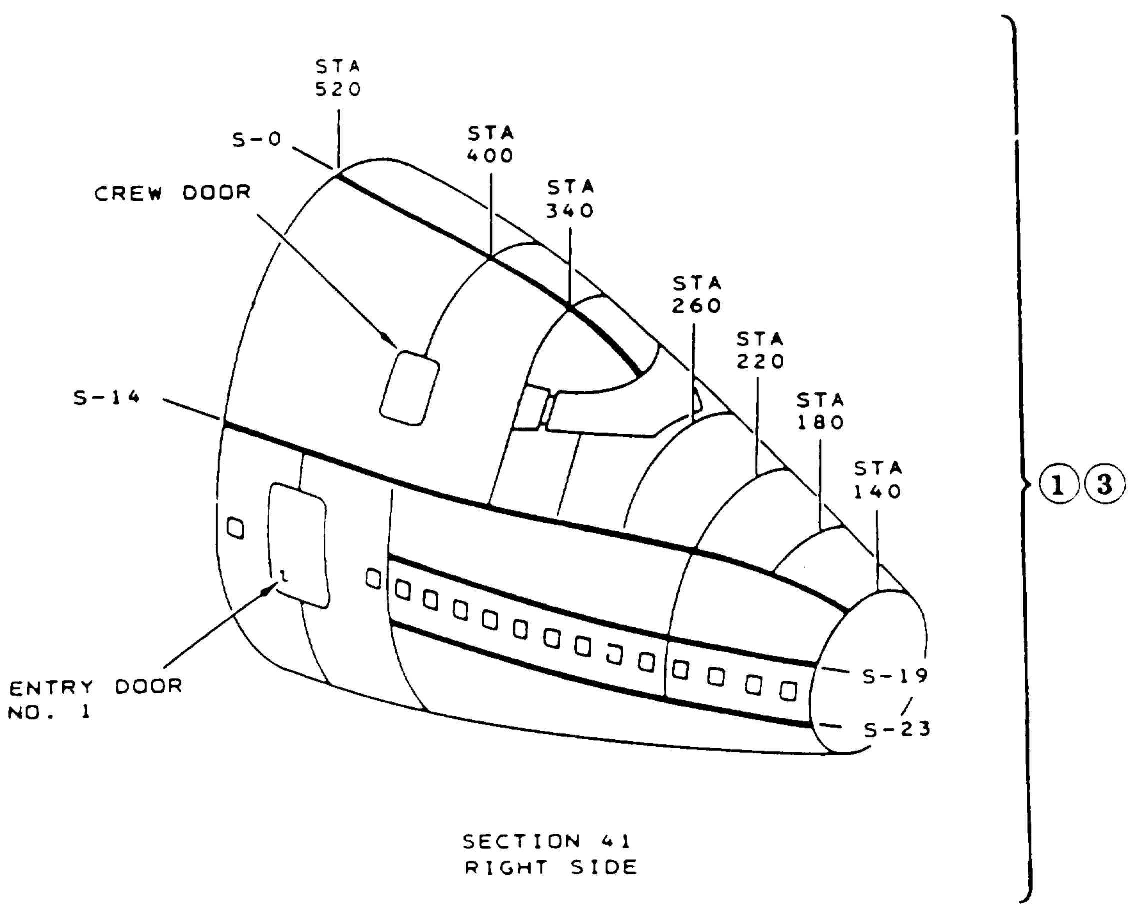


FIGURE 2. EXTERNAL LAP JOINT CORROSION INSPECTION (CONTINUED)

BOEING SERVICE BULLETIN 747-53-2307

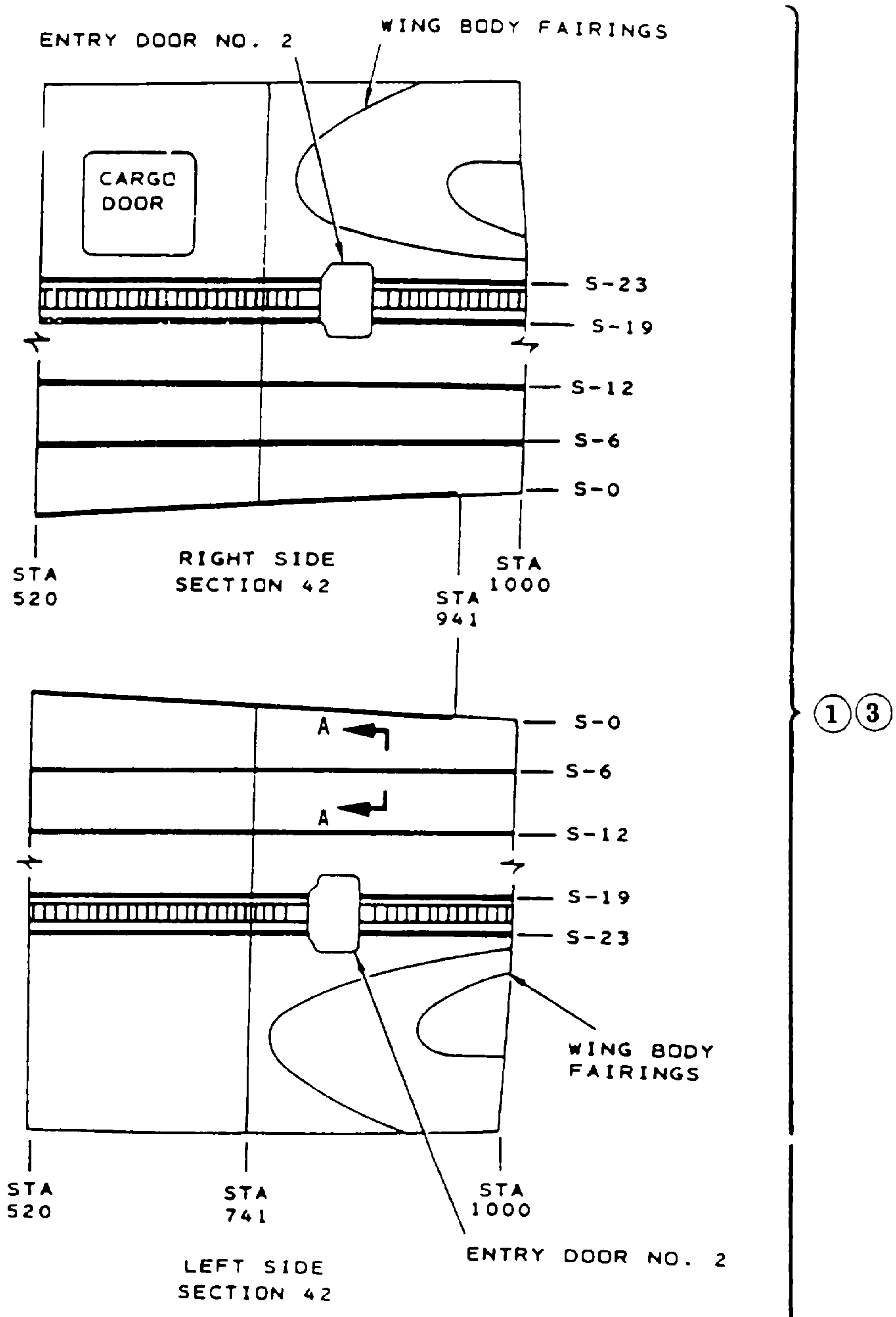


FIGURE 2. EXTERNAL LAP JOINT CORROSION INSPECTION (CONTINUED)

BOEING SERVICE BULLETIN 747-53-2307

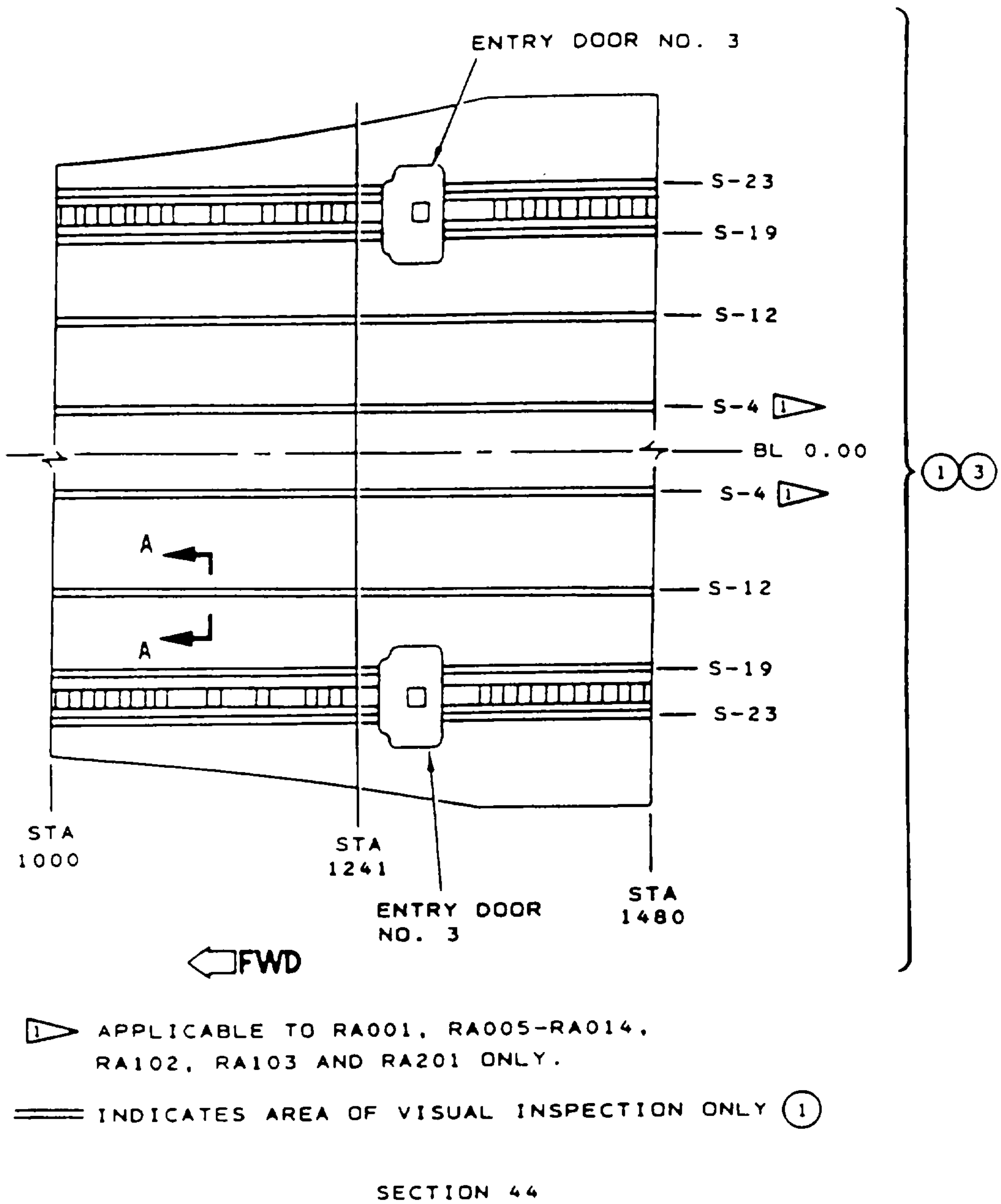


FIGURE 2. EXTERNAL LAP JOINT CORROSION INSPECTION (CONTINUED)

BOEING SERVICE BULLETIN 747-53-2307

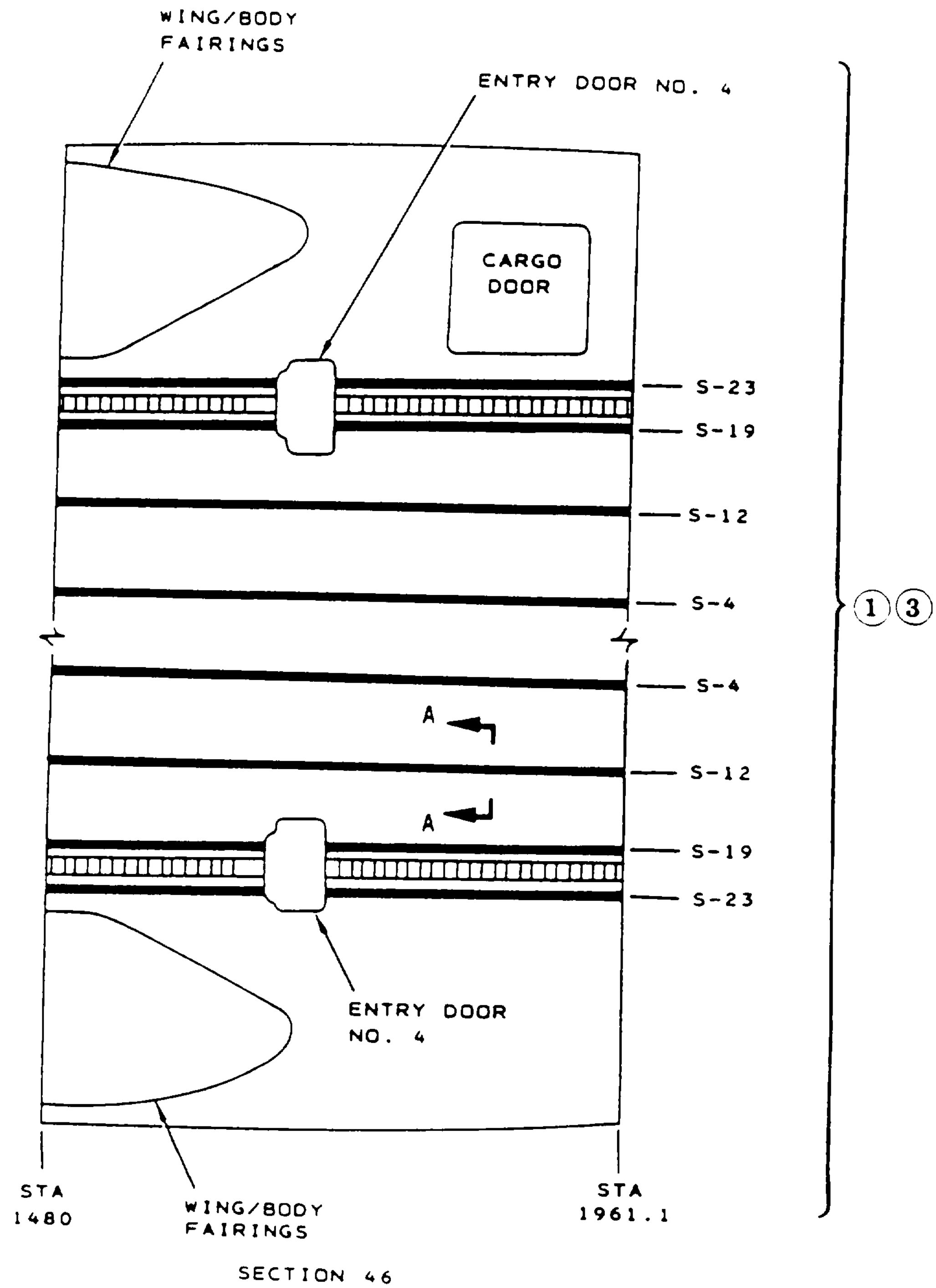


FIGURE 2. EXTERNAL LAP JOINT CORROSION INSPECTION (CONTINUED)

BOEING SERVICE BULLETIN 747-53-2307

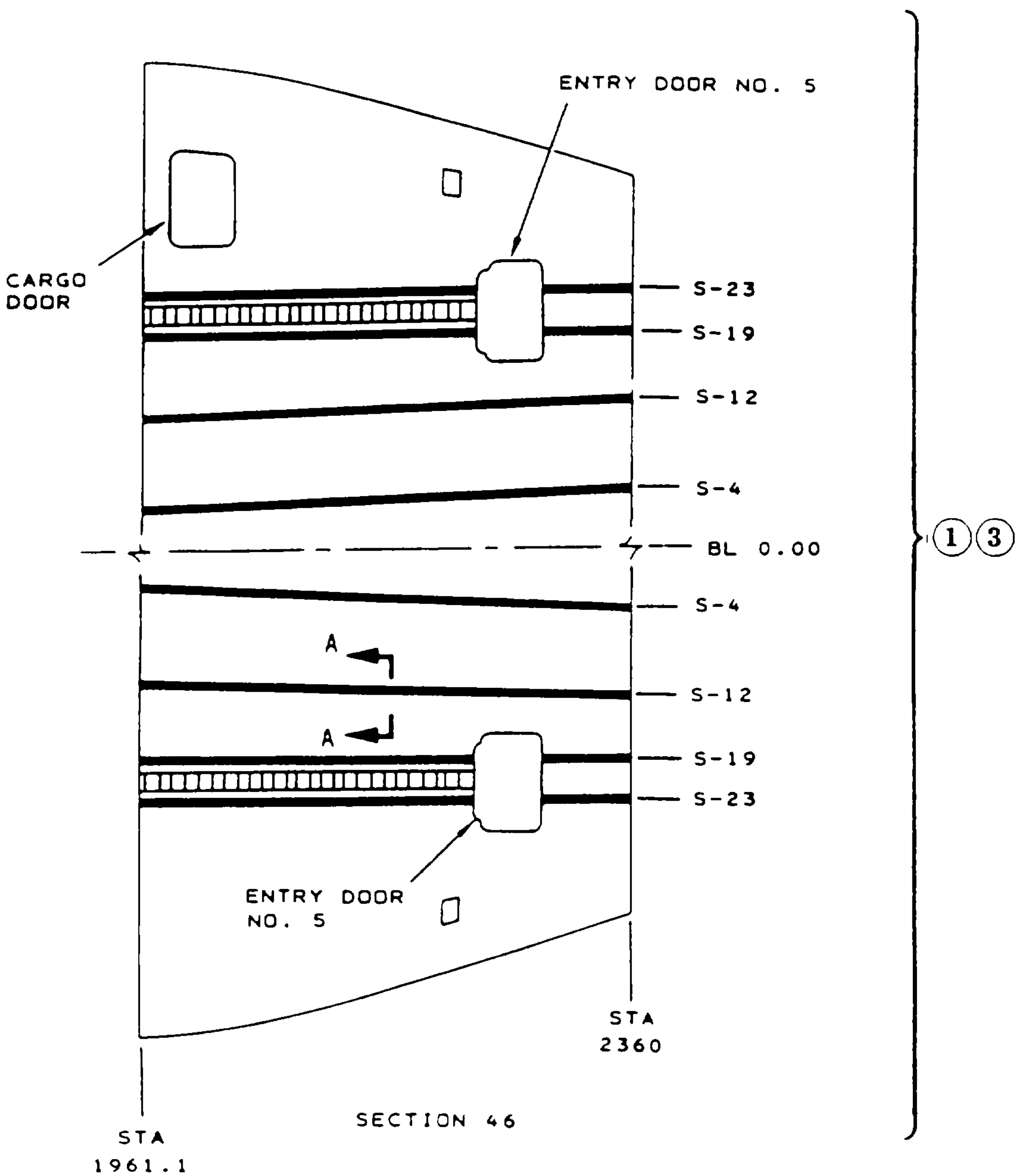


FIGURE 2. EXTERNAL LAP JOINT CORROSION INSPECTION (CONTINUED)

BOEING SERVICE BULLETIN 747-53-2307

(3) Perform the following applicable action(s):

a. For lap joint areas with cracking or corrosion completely through the skin, repair per 747 Structural Repair Manual Subject 53-30-03 prior to further pressurized flight

b. For missing or distressed fasteners, replace fastener per 747 Structural Repair Manual Subject 53-30-03, Figure 9 or 10, prior to next pressurized flight.

c. For lap joint areas with skin bulging or pillowing in excess of 0.010 inch, repair per 747 Structural Repair Manual Subject 53-30-03 unless the following three conditions have been met:

1. Inspection per 747 Non-Destructive Test Manual D6-7170, Part 6, Subject 51-00-00, Figure 5 indicates that material loss does not exceed 10 percent.

2. No evidence of skin cracks or corrosion completely through the skin is found.

3. For Section 46, tear straps have been reworked by temporary repair or terminating action per Service Bulletin 747-53A2279 in adjacent area.

NOTE: Adjacent area refers to the area bounded by the 3 stringer bays above and below the applicable lap joint and the closest tear strap forward and aft of the corroded area. Where corrosion is within 5 inches of a frame, the next distant tear strap from and not the tear strap closest to that frame determines that boundary.

d. For lap joint areas where measured material loss does not exceed 10 percent, reinspect per this service bulletin at 500 flight-cycles as specified in the procedure (Method I or II) being used. Terminating action must be performed on corroded lap joint (from forward circumferential splice to aft circumferential splice) within 30 months of being found.

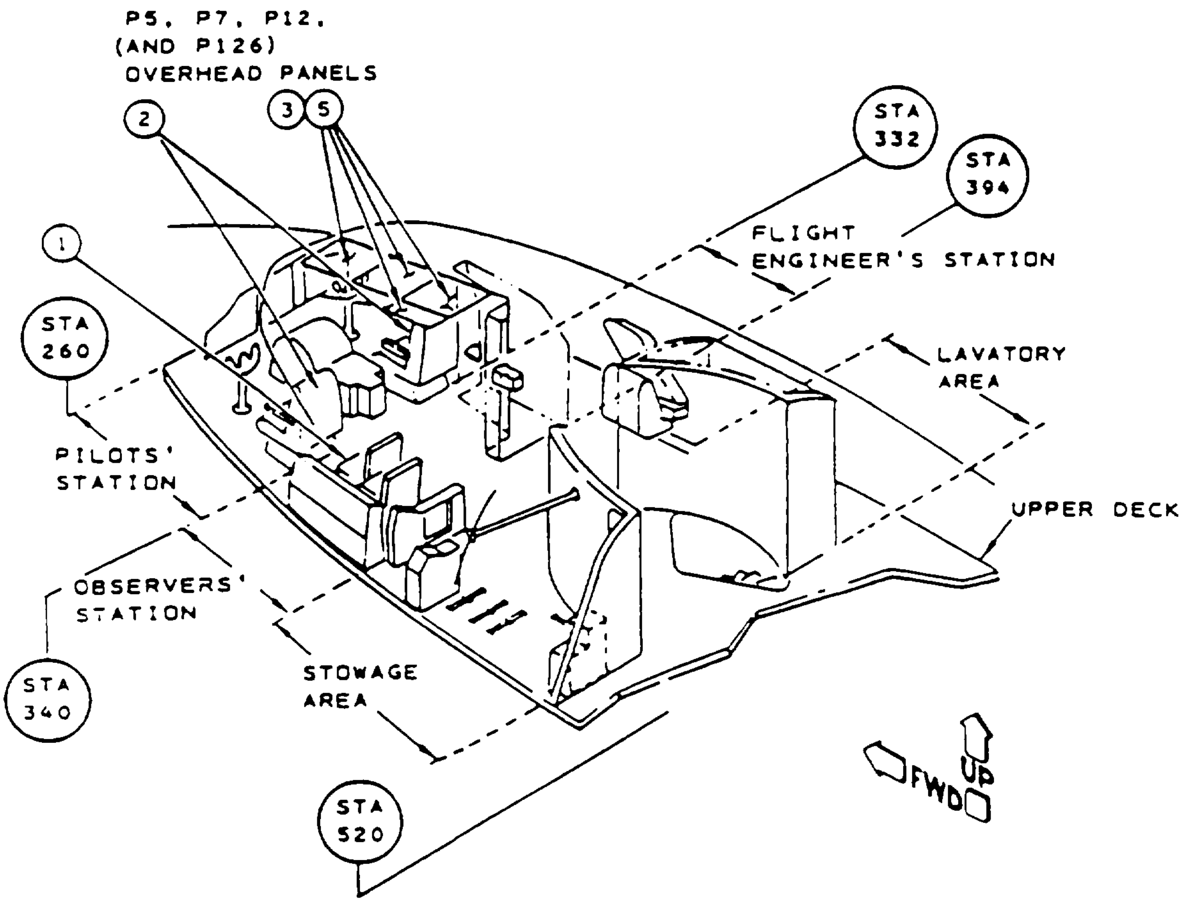
e. For lap joint areas where material loss is greater than 10 percent, repair per 747 Structural Repair Manual Subject 53-30-03 prior to next pressurized flight.

f. For any lap splice which is required to be repaired per 747 Structural Repair Manual Subject 53-30-03, terminating action must be performed on the remaining unrepaired length of the skin panel (from forward circumferential splice to aft circumferential splice of repaired skin panel) within 15 months of the repair. If existing repairs are found during the initial visual inspection of this bulletin, terminating action must be accomplished on the remaining unrepaired length of the skin panel within 15 months of being found.

FIGURE 2. EXTERNAL LAP JOINT CORROSION INSPECTION (CONTINUED)

Dec 21/89 747-53-2307

BOEING SERVICE BULLETIN 747-53-2307



TYPICAL FLIGHT DECK INSTALLATION
ALL AFFECTED CONFIGURATIONS SIMILAR

FIGURE 3. FLIGHT DECK LAP JOINT INTERNAL ACCESS

Dec 21/89

747-53-2307

BOEING SERVICE BULLETIN 747-53-2307

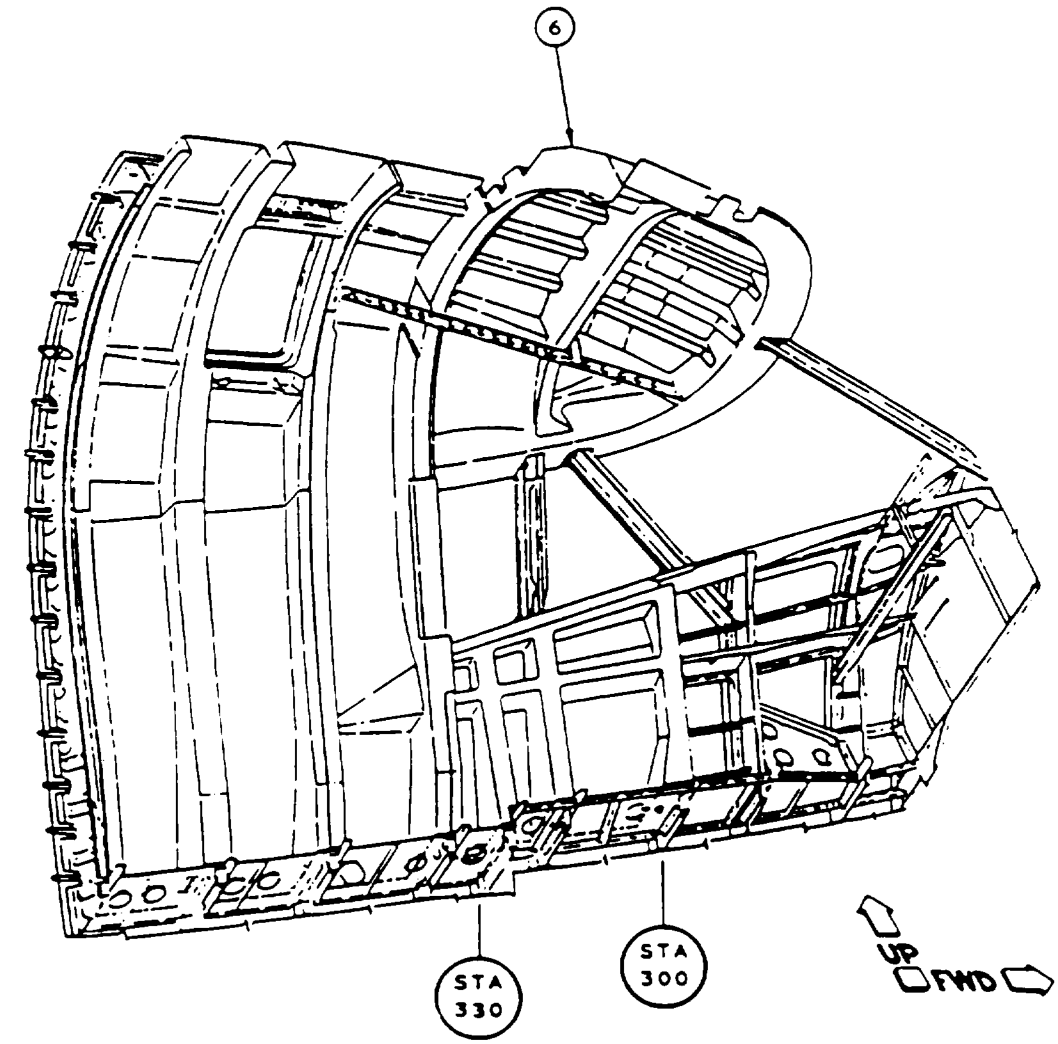


FIGURE 3. FLIGHT DECK LAP JOINT INTERNAL ACCESS

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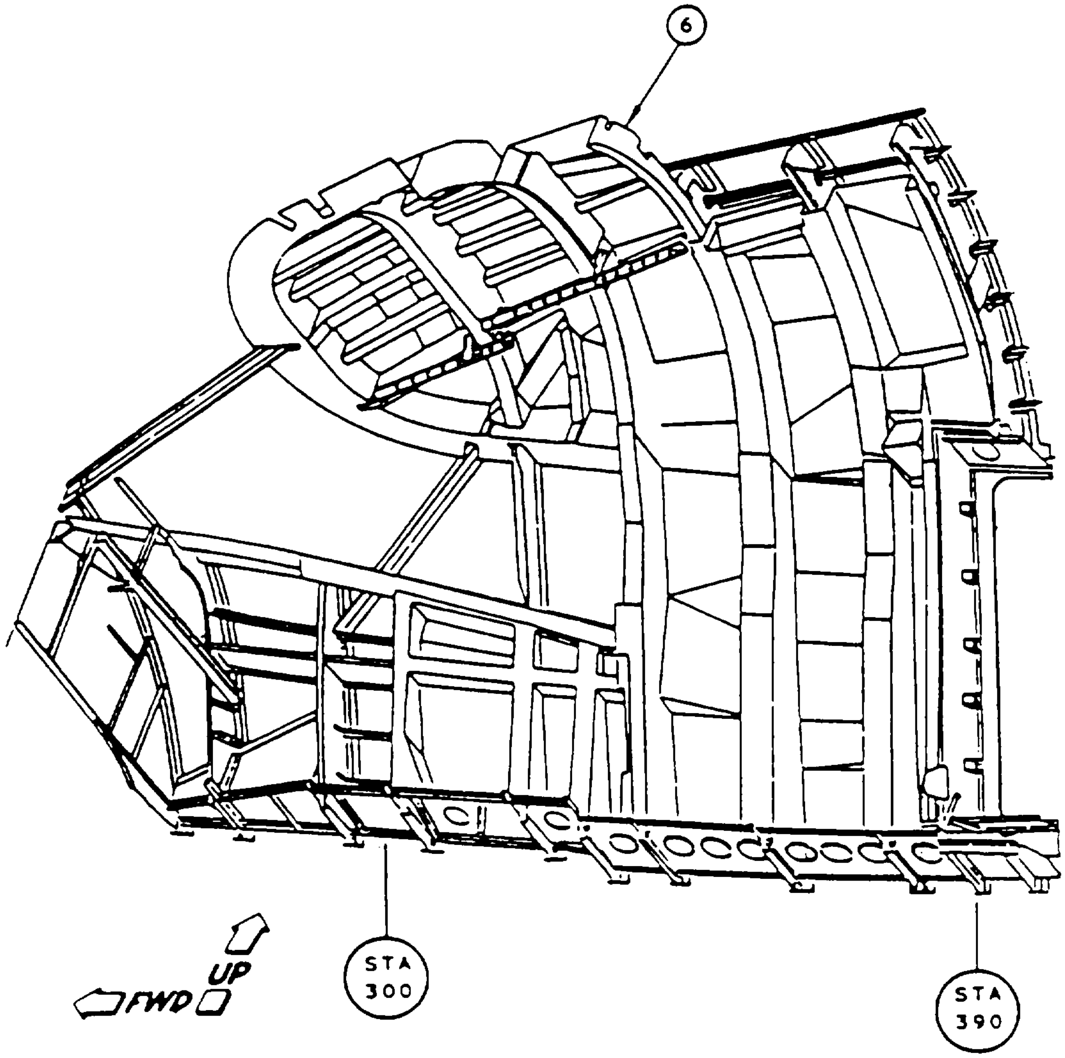


FIGURE 3. FLIGHT DECK LAP JOINT INTERNAL ACCESS (CONTINUED)

Dec 21/89 747-53-2307

BOEING SERVICE BULLETIN 747-53-2307

(1) Remove the flight engineer's seat per 747 Maintenance Manual Subject 25-11-02 or operator's comparable procedure. Remove the observer's seat per 747 Maintenance Manual Subject 25-11-03 or operator's comparable procedure. Remove the crew seat per 747 Maintenance Manual Subject 25-11-05 or operator's comparable procedure.

(2) Remove the pilot's seats per 747 Maintenance Manual Subject 25-11-01, or operator's comparable procedure.

(3) Remove the pilots' overhead panel P5 and circuit breaker panels P7, P12 (and P126 if installed). Reference 747 Maintenance Manual Subject 31-00-00.

(4) Not shown - Cover pedestal, panels, racks, and all wire bundle connectors with plastic sheets to help prevent contamination or damgage of equipment.

(5) Remove and salvage disconnect panels behind the pilots' overhead panel P5 and circuit breaker panels P7 and P12. Disconnect wire bundles as required to enable disconnect panels to be moved clear of modification area for dripshield removal.

NOTE: Prior to disconnecting any wire bundles from disconnect panels, removing any wire bundles from wire bundle clamps or disconnecting any separate ground wires, ensure that all wire bundles and separate wires are identified and suitably marked for reinstallation.

(6) Remove and salvage the overhead sidewall linings, moldings, dripshields, and insulation in flight deck area per 747 Maintenance Manual Subject 25-14-01 or operator's comparable procedure.

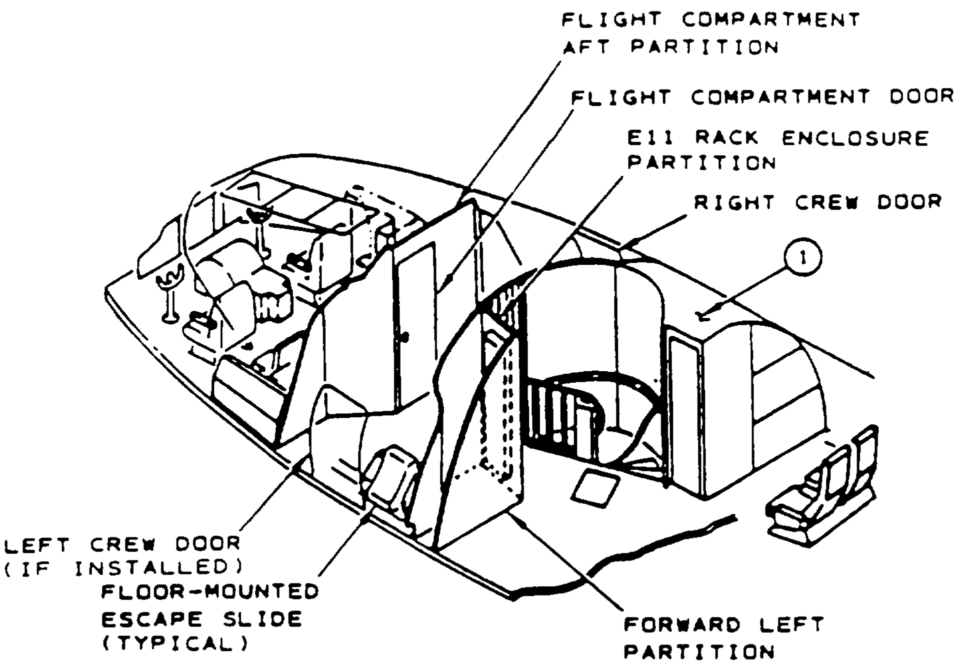
(7) Not shown - Loosen and deflect any installed pitot static tubing as required in modification areas per 747 Maintenance Manual Subject 34-11-00 or operator's comparable procedure.

(8) Not shown - Loosen and deflect, or remove any oxygen tubing in modification areas, as required per 747 Maintenance Manual Subject 35-00-00 or operator's comparable procedure.

(9) Not shown - Remove crew escape hatch per 747 Maintenance Manual Subject 53-21-01 or operator's comparable procedure.

FIGURE 3. FLIGHT DECK LAP JOINT INTERNAL ACCESS (CONTINUED)

BOEING SERVICE BULLETIN 747-53-2307



TYPICAL UPPER DECK CONFIGURATION
WITH LEFT AND RIGHT CREW DOOR
(OTHER UPPER DECK CONFIGURATIONS SIMILAR)

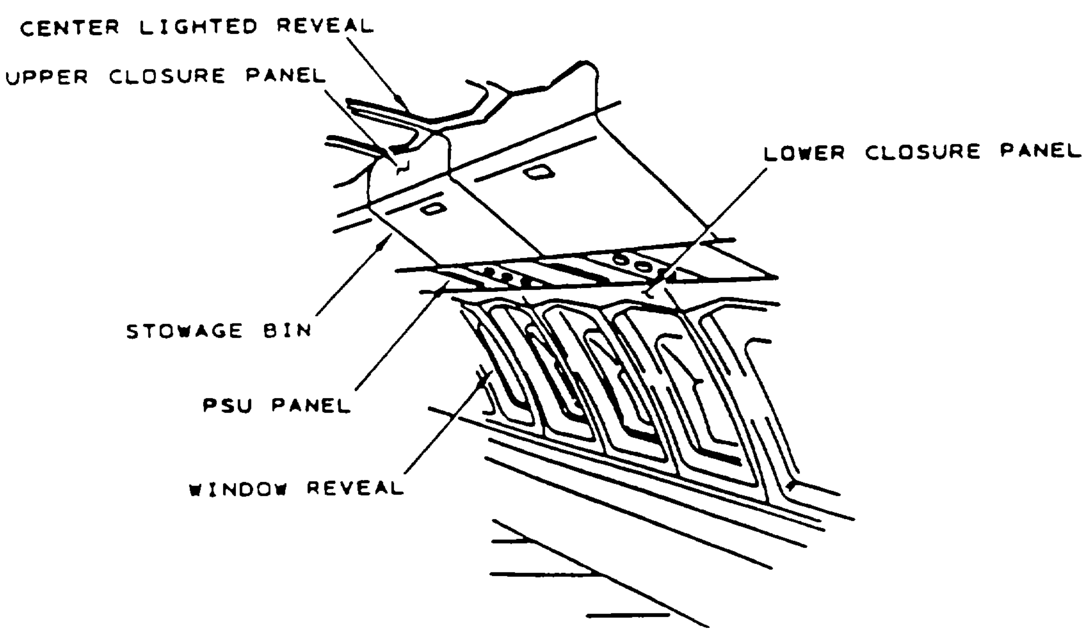


FIGURE 4. UPPER DECK LAP JOINT INTERNAL ACCESS

BOEING SERVICE BULLETIN 747-53-2307

1 Remove and salvage equipment and furnishings as required to gain access to STA 420 through STA 520 lap joints. Refer to the following maintenance manual subjects for removal procedure.

Equipment	Maintenance Manual Subject
Window Reveal	25-21-02
Sidewall and Ceiling Insulation	25-21-04
Ceiling Panels	25-22-03
Passenger Service Units	25-23-01
Forward Closets	25-24-00
Forward Right Partition	25-24-11
Forward Left Partition	25-24-12
Crew Rest Area	25-24-19
Passenger Seats	25-25-01
Wall Mounted Attendant Seat	25-25-04
Stairway Forward Right Partition	25-26-02
Stair Aft Right Partition	25-26-03
Stairway Forward Left Partition	25-26-06
Sidewall Stowage Units	25-28-15
Overhead Stowage Bins	25-28-23
Lavatories	25-40-03
Floor Mounted Escape Slide	25-68-02
Crew Entry Door	52-13-01
Flight Compartment Door	52-51-01

2 Not shown - Install all items which are removed in the preceding step per the applicable maintenance manual subject or operator's comparable procedure.

FIGURE 4. UPPER DECK LAP JOINT INTERNAL ACCESS (CONTINUED)

BOEING SERVICE BULLETIN 747-53-2307

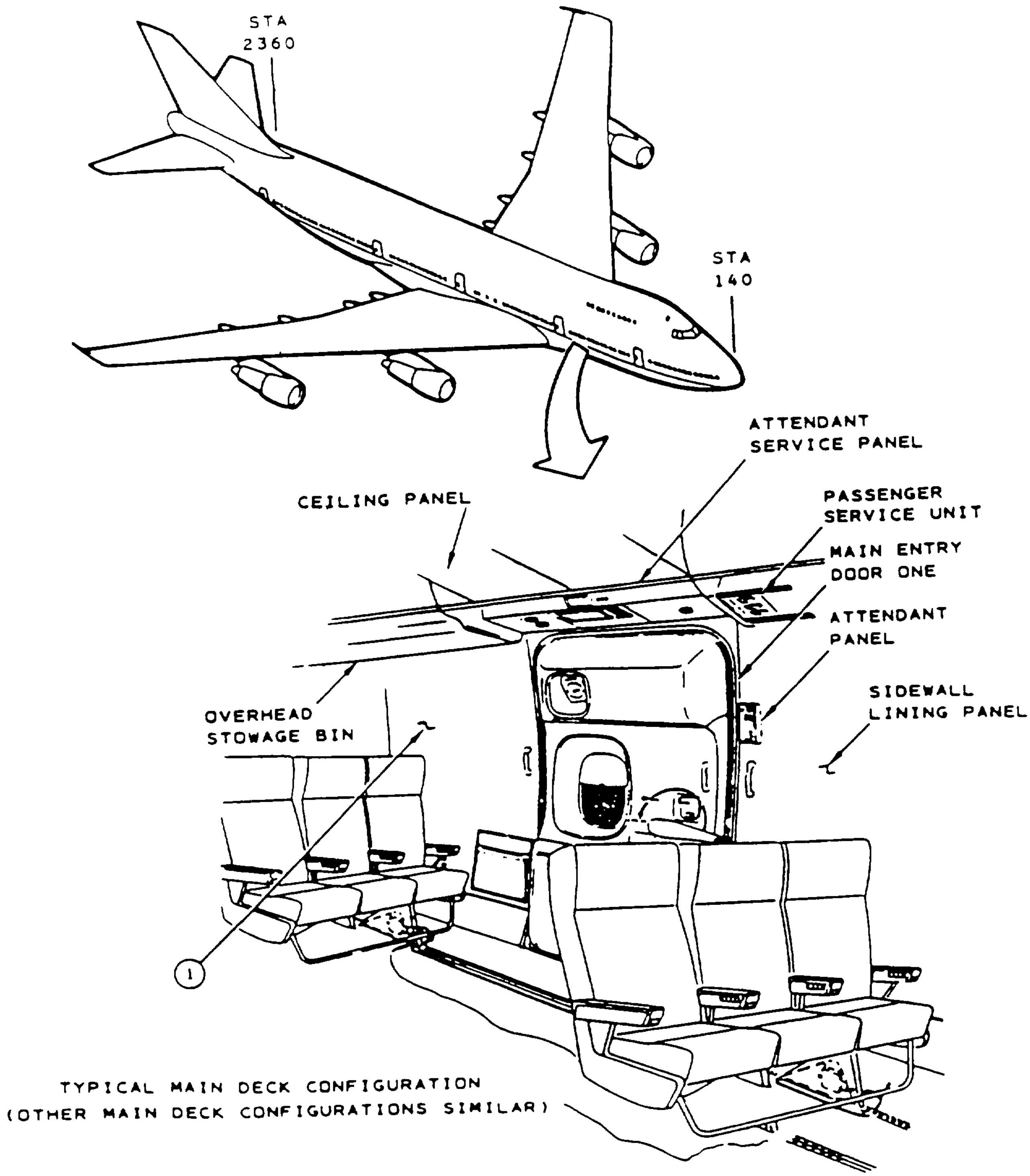


FIGURE 5. MAIN DECK LAP JOINT INTERNAL ACCESS

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747-53-2307

BOEING SERVICE BULLETIN 747-53-2307

NOTE: To prevent damage to floor panels, it is recommended that a 1/2-inch thick, 1-foot square plywood bearing pad be used under each leg of ladders, stands or scaffolds. Additionally, it is also recommended that only one person be allowed to use each ladder, stand or scaffold.

(1) **Remove and salvage equipment and furnishings as required to gain access to STA 140 through STA 2360 lap joints. Refer to the following maintenance manual subjects for removal procedure.**

Equipment	Maintenance Manual Subject
Sidewall Lining Panels	25-21-01/-02
Sidewall and Ceiling Insulation	25-21-04
Sidewall Dado Panels	25-21-12
Ceiling Panels	25-22-01/-03
Entryway Ceiling Panels	25-22-06
Passenger Service Units	25-23-01
Attendant Service Unit	25-23-04
Forward Closets	25-24-00
Partitions	25-24-05
Passenger Seats	25-25-01
Track Mounted Attendant Seats	25-25-03
Wall Mounted Attendant Seats	25-25-04
Floor Covering	25-27-00
Insulation Blankets	25-28-01
Overhead Stowage Bins	25-28-23
Sidewall Galleys	25-31-04
Sidewall Lavatories	25-40-01
Cargo Lining Panels	25-59-01
Attendant Panel	25-23-05
Oxygen Tubing	35-21-00
Main Entry Door No. 1	52-11-01
Floor Panels	53-21-02

(2) Not shown - Install all items which are removed in the preceding step per the applicable maintenance manual subject or operator's comparable procedure.

FIGURE 5. MAIN DECK LAP JOINT INTERNAL ACCESS (CONTINUED)

APPENDIX G. VISUAL INSPECTION EQUIPMENT

VISUAL INSPECTION EQUIPMENT

MANUFACTURER OF SUPPLIER	VISUAL INSPECTION EQUIPMENT SUPPLIED
Circon ACMI P.O. Box 1971 Stamford, CO 06904 (203) 328-8751	Remote viewing instruments and systems: borescopes; borescope video systems; and high-intensity light sources.
Fibertron Inc. 600 N. Shepherd Bldg. 115 Houston, TX 77007 (713) 861-3602	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.
Instrument Technology Inc. P.O. Box 381 Westfield, MA 01086 (413) 562-3606	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.
Learjet/Bombardier PO Box 7707 Wichita, KS 67277-7707 Attn. Spares Dept.	Larascope—Optical Prism Inspection System
Lenox Instrument Co., Inc. 265 Andrews Road Scottsville Industrial Park Trevose, PA 19047 (215) 322-9990	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.
Machida Inc. 40 Ramland Road South Orangeburg, NY 10962 (914) 365-0600 (800) 431-5420	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.
McMaster-Carr Supply Co. P.O. Box 4355 Chicago, IL 60680-4355 (708) 833-0300	Industrial luminaires: adjustable arm lights; portable utility lights; incandescent and fluorescent trouble lights; borescopes; fiber optic illuminators and light guides; inspection mirrors; and flashlights.
Mitsubishi Cable America, Inc. 520 Madison Avenue New York, NY 10022	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.
Moritex USA, Inc. 6440 Lusk Blvd. Suite D-105 San Diego, CA 92121	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.
Newco, Inc. P.O. Box 4013 Florence, SC 29502 (803) 669-2988	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.
Olympus Corp. Industrial Fiberoptics Division 4 Nevada Drive Success, NY 11042-1179 (516) 488-3880	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.

MANUFACTURER OF SUPPLIER	VISUAL INSPECTION EQUIPMENT SUPPLIED
Optical Gaging Products Inc. 850 Hudson Ave. Rochester, NY 14621 (716) 544-0400	Optical instruments: optical comparators and measuring microscopes.
Optronics Engineering University Business Center 175B Cremona Drive Goleta, CA 93117	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.
Richard Wolf Medical Instruments Corp. Industrial Division 7046 Lyndon Ave. Rosemont, IL 60018 (708) 298-3150	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.
Schlueter Instruments Corp. Gunbarrel Square Suite 320 6525 Gunpark Drive Boulder, CO 80301 (303) 530-2217	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.
Shott Fiber Optics Inc. 122 Charlton Street Southbridge, MA 01550 (508) 765-9744	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.
Titan Tool Supply Co., Inc. 68 Comet P.O. Box 182 Buffalo, NY 14216	Optical instruments: measuring and alignment microscopes; toolmakers microscopes; flexible and rigid borescopes; high-intensity light sources; fiber optic light sources and light guides; etc.
Welch Allyn Inc. Inspection Systems Division 4619 Jordan Road P.O. Box 100 Skaneateles Falls, NY 13153	Remote viewing instruments: industrial borescopes; borescope video systems; and high-intensity light sources.

APPENDIX H. ENGINE VISUAL INSPECTION GLOSSARY

Engine Visual Inspection Glossary. Retyped with Permission of Pratt & Whitney.

ENGINE VISUAL INSPECTION GLOSSARY
(Courtesy of Pratt & Whitney)

GLOSSARY OF TERMS: The following defines terms used in this Master and other VIS's.

Abrasion: A rubbing away of coating material which may or may not expose base metal.

Back-To-Back Imperfections: Imperfections on the opposite faces of a specific wall (or weld) which normally are opposite each other (see Figure H-1). This condition is considered evidence of a single thru-wall imperfection. If it is obvious that discontinuities on opposite faces are caused by the same defect. Even though offset, this condition is considered back-to-back (see Figure H-2).

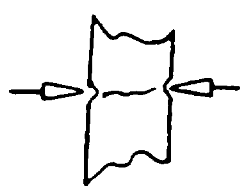

Figure H-1. Single Thru-Wall

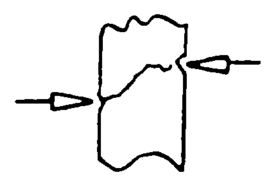

Figure H-2. Back-To-Back

Bellmouth: Taper condition formed on ID of a hole at the opposite end of the hole from which a punch or blanking die enters.

Blending: An operation which removes an irregularity from a surface, resulting in a shallow, smooth depression.

Blister: A localized lifting of coating, plating, fiberglass, or paint, appearing as a bulge that may break when probed.

Bottomed Imperfection: Pit, cavity or hole in which the bottom can be seen.

Braze Crack: Linear fracture of the braze surface.

Braze Fillet: Braze in a joint creating a smooth transition between the details being joined.

Braze Joint: Area between details to be joined by brazing.

Braze Porosity: A group of closely-spaced, small voids (internal pores) in the braze joint or fillet open to the braze surface.

Braze Rippling: A condition of the braze surface characterized by unevenness and irregular appearance with peaks and valleys that are gradual in nature, like ripples on a pond.

Braze Void: Unfilled space in braze material in which a bottom is visible.

Broach Mark: A straight depressed imperfection without tears, caused by the broaching operation (See Tool Mark).

Burnish: A shiny area resulting from rubbing against a hard, smooth surface; may contain scratches of no apparent depth.

Burnishing: Mechanical smoothing of a surface, usually by rubbing.

Burn Marks: Localized indication of excessive heating (e.g., blue to blue-black discoloration) due to excessive dwell time of a tool at that location, or electrical arcing due to improper contact between an electrode and the part.

Burn Out: Electro-chemical machining erosion beyond the desired feature profile.

Burr: A fragment of metal which remains attached to the surface after a machining or riveting operation.

Burst: Cracks caused by rupture extending outward from a central point.

Chain Porosity: Porosity in linear alignment.

Chatter Mark: Recurring undulations or irregularities that result from vibratory interactions of the tool and a typical machined surface.

Chips or Chipping: Discrete particles of a coating which have been removed by mechanical means.

Clearly Separated: Imperfections which are not touching when viewed with the unaided eye.

Cluster: Two or more imperfections, clearly separated, which can be contained within a circle of the maximum diameter allowed by the assigned standard. A cluster, or group of clusters which can be contained within the allowed circle shall be counted as one imperfection.

Cold Shut: Intermittent or continuous lines caused by unused material.

Corrosion: Surface is pitted and discolored, caused by unwanted chemical or electrochemical action.

Crack: Linear imperfection in the form of a narrow break or fissure of the surface.

Crater: A depression at the termination of a weld bead.

Crazing: A network of minute cracks appearing in the coating of coated parts.

Delamination: A separation of the layers in a layered material.

Dent: A surface depression normally having rounded edges, corners, and bottom, caused by the impact of some object.

Depressed Imperfection: Imperfection below the general surface of the part; may have either smooth or irregular (sharp) edges or bottom (See Dent or Pit).

Die Break or Breakway: A rough surface caused by breaking away of metal by a punch or blade during a blanking or shearing operation.

Draw Mark: Linear, trough-like grooves which result from the action of die imperfections or foreign material on the drawn material.

Dross: Linear imperfections or imperfections in the form of branching or irregular patterns, caused by impurities or oxides in a cast material.

Erosion: The carrying away of material by the flow of gases, fluids or solids.

Excess Braze: Braze material beyond the joint fillet; sometimes referred to as a run, streak or flash.

Fissure: Linear imperfection in the form of a narrow separation of surface material.

Flaking: Raised areas of coating or plating on a coated or plated part, indicative of poor bonding.

Foreign Material: Any solid or liquid material not integral to a part. Such material may or may not be adherent to a surface or passage.

Forging Mark: Ridges or grooves on the external surface of a part caused by foreign material or irregularities on the forming die.

Formed Depression: A change in surface level caused by mismatch of adjoining die segments.

Fretting Corrosion: A rapid oxidation of surfaces caused by movement of closely fitted parts. It is characterized by surfaces exhibiting colors ranging from black to brick red, depending upon severity and/or time of exposure to fretting corrosion.

Fusion Line: Interface of the weld bead and parent metal.

Fusion Zone: The weld bead formed by the melting of filler metal and parent metal, or of parent metal only.

Galling: An advanced case of fretting corrosion where there is transfer of material from one to the other of closely fitted surfaces, causing damage to both surfaces.

Gas Path: Engine airstream area.

Gouge: Relatively wide trough-like depression caused by tearing away of the surface by another object.

Grinding: An operation that removes material by the use of an abrasive material to produce a predetermined size.

Groove: A narrow cut in a surface.

Heat Affected Zone: The zone on each side of the weld bead on both the weld deposit and melt thru sides, when applicable. The width of the heat-affected zone shall be one half the width of the weld bead. See Figure H-3.

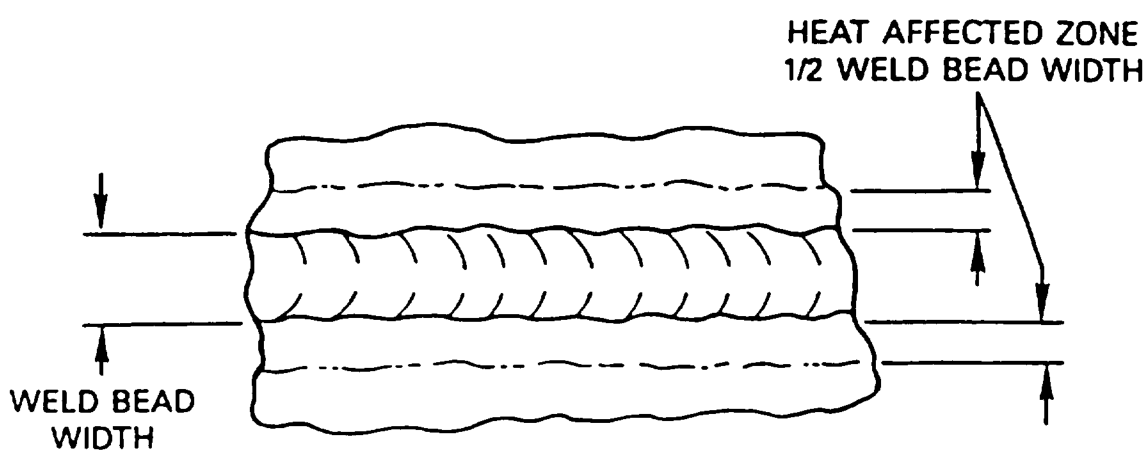

Figure H-3. Typical weld deposit and melt thru sides

Heat Discoloration: Staining, ranging from straw color (low temperature effects) to purple (high temperature effects).

Hot Tear: Linear fractures in the form of ragged wavy lines of variable width resulting from overstress of the material during solidification.

Imperfection: An interruption (non-uniformity) in the normal surface condition of a part configuration which must be evaluated for acceptance to an assigned standard.

Inclusion: A linear or non-linear entrapped foreign material particle retained in the metal during solidification.

Incomplete Fusion: A linear imperfection of varying width caused by failure of the weld material to fuse during a welding operation.

Interface: A common boundary of two pieces, spaces or phases.

Kink: A buckled condition, a short tight twist or curl in tubing caused by a bending or winding of the tubing.

Lap: A linear imperfection caused by folding over of metal edges during rolling or forging operations.

Linear: An imperfection having a length three or more times its width.

Linear Alignment: Three or more aligned imperfections separated from one another by less than three times the maximum imperfection dimension.

Line of Braze: Visible braze material in the joint; includes recessed braze and depressed imperfections in which the bottoms can be seen.

Major Dimension: The longest dimension of an imperfection.

Minor Dimension: The smallest dimension of an imperfection.

Nick: A small surface imperfection having sharp edges, corners, or bottom caused by impact of a sharp object.

Nodule: A small, rounded, raised lump of metal, plating or coating material.

Non-Bottomed Imperfection: A depressed imperfection in which the bottom cannot be seen.

Non-Linear Imperfection: An imperfection whose length is less than three times its width.

Oil Canning: Localized buckling or distortion of a smooth, thin-wall contour, usually caused by weld mismatch or weld shrinkage.

Orange Peel: A dimpled or grainy surface texture resembling an orange peel.

Peeling: Section of a coating or plating lifting away from the coated or plated surface.

Per Inch of Weld: One inch of weld bead length regardless of weld width. A shifting of an imaginary scale having one inch increments along the weld is required to contain the maximum number of imperfections in a one inch length.

Pit: Small irregular cavity in a surface, usually dark bottomed.

Plating Pit: A rounded depression in the surface of the plating which does not expose base material.

Polishing: A finishing operation which produces a smooth surface finish.

Porosity: A series of holes or pits caused by air or gas trapped in the metal during solidification.

Raised Edge: A narrow ridge of material along an edge raised above the general contour of the part.

Raised Imperfection: An imperfection which is above the general surface of the part.

Recessed Braze: Braze around the joint which falls below the theoretical full joint surface.

Rollover: A rounded edge formed on the side of a part from which a punch or blanking die enters.

Run: See 'Excess Braze'

Scoring: Multiple scratches caused by contact with a mating part, foreign material or tool.

Score Line: A deep scratch caused by an irregular mating surface.

Scratch: A linear depression with a sharp bottom caused by movement of a sharp object or particle across the surface.

Scuffs: Small closely spaced scratches caused by the rubbing together of hard surfaces.

Seam: Linear imperfection attributable to an unused material condition which existed prior to metal working operations; variation of a lap.

Shallow Imperfection: An imperfection which appears to penetrate the surface finish texture, does not have a dark bottom and would not cause a stylus having a nose radius ranging in size from .030" to .0365" (Steel, TAM 167120 or 170194 or equivalent) to hesitate (catch) when passed over it.

Shear Mark (Die Break): A rough surface caused by breaking away of metal during die-forming operations.

Shrinkage: Linear or non-linear imperfections of varying forms caused by contraction during solidification.

Smooth: A surface that is continuously even, free of irregularities, presenting no resistance to the sliding of a finger or tool. Can be applicable to a one plane surface or transition surfaces between planes.

Spalling: Breakdown of the surface (cracking, flaking) due to fatigue, usually in the form of irregular, sharp edged pits with edge conditions indicating progression. May be caused by subsurface inclusions, in which case the bottom of the pit may be dark.

Spatter: Molten material expelled from a weld which adheres to nearby surfaces.

Stain: Surface discoloration due to liquids drying on the part.

Step: An abrupt change in the surface contour which looks like a step in cross section.

Stretch Mark: A condition where material has been elongated during forming to the point of producing a rippled surface.

Stringer: Impurities in a metal which are elongated by rolling or forming operations. May appear as a continuous line or a series of elongated pits or inclusions.

Superficial Imperfection: An imperfection which disrupts the surface and appears smooth-edged but does not penetrate the surface roughness texture. This condition is so slight, considered less than a shallow imperfection, that a stylus need not be used to evaluate it.

Surface Texture (Finish): The texture of a surface, be it forged, cast or machined. Also, this term applies to the numerical value assigned to the surface roughness of machined surfaces.

Surface Roughness: Marks left on the workpiece by the action of a tool, such as a grinding wheel or a lathe tool.

Tear: Removal of metal by tensile stresses imposed by a dull tool or too heavy a cut.

Through Void: A void which extends completely through a braze or weld. If it is impossible to see through the void, it is considered through if no bottom can be observed.

Tool Mark: Imperfection, usually depressed, caused by machining tools.

Void: Regular or irregular shape imperfections resulting from lack of braze or weld material.

Warped: Twisted or distorted out of shape because of unequal internal stresses introduced in forming or thermal operations.

Weld Undercut: A groove in the parent metal adjacent to an edge of a weld left unfilled by the weld operation.

Well Dispersed: Imperfections separated from one another by 125 inches or more.

Woodgraining: A general surface condition consisting of smooth-bottomed, elongated pits connected by light surface cracks.

Wrinkle: A rippled surface that occurs in areas of sharp contour changes in sheet metal parts.

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